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PATHOLOGICAL STUDIES OF *CERCOSPORINA RICINELLA* (SACC ET BERL.) SPEG. CAUSING LEAF-SPOT DISEASE OF CASTOR (*RICINUS COMMUNIS* LINN.)

By

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[Received on May, 26 1962]

Many species of *Cercosporina* including *C. daturicola* (on *Datura* sp.), *C. sensitivae* (on *Mimosa sensitiva*), *C. jatrophicola* (on *Jatropha* sp.), *C. lappae* (on *Artium lappa*), *C. kikuchii* (on *Glycine soja*) and *C. ricinella* (on *Ricinus communis*) are known to be pathogenic on various plants but no detailed studies have been carried out on any of them.

The leaf-spot disease of castor caused by *Cercosporina ricinella* has been reported from India and other countries of the world. Butler (1918) recorded this disease from Pusa and other parts of India. Ciferri and Frogoos (1926) noted it in Dominion Republic. Curzi (1932) found this disease in the Italian Somaliland. It has also been observed in North America, Australia, Ceylon and China.

This crop is of great importance for our country because India is one of the most important supplier of castor seed in the world. It was decided to undertake detailed physiological and pathological studies of *Cercosporina ricinella* which is responsible for the leaf-spot disease of *Ricinus communis* because so far this organism has not been studied. The present paper deals with the pathological studies only.

Material and methods :

Symptoms of the disease were noted from the naturally infected leaves and they were compared with those developed as a result of the artificial inoculations. The morphological characters of the causal organism on the host were noted. The host-parasite relationship was studied by examining a number of serial sections of the naturally infected leaves. The usual cytological techniques were followed for preparing such sections.

Pathogenicity tests were conducted on young and old leaves. For this purpose plants of *Ricinus communis* were taken and their old as well as young leaves

were inoculated (on both the surfaces) with *Cercosporina ricinella*. Inoculations were made on injured and uninjured surfaces. The following three methods were used for inoculating the leaves :

1. *Mass inoculation method* : In this method a mass of spores and mycelium was placed on the injured or the uninjured surfaces of the leaves.
2. *Spore suspension method* : In this method a suitable spore suspension was prepared and it was sprayed on the leaves.
3. *Germinating spore suspension method* : This method was similar to the second except for the fact that the spores were germinated in 0·2% peptone solution before spraying.

Controls were simultaneously arranged in every case and except for the absence of the fungus in such cases all other conditions were similar in the two series. Reisolations were always made in order to confirm that the infetcion was caused by the organism which was inoculated. Cross inoculations were carried out on various parts of the host as well as on different parts of other plants. Fruits were inoculated by the method suggested by Granger and Horne (1924).

Mode of spore germination was studied by the hanging drop technique described by Hoffman (1860). The effect of nutrients on spore germination was studied by the method suggested by Lilly and Barnett (1951).

The fungicides were evaluated in the laboratory before using them on plants. Fosberg's (1949) technique was followed for this purpose. The fungicides which were found suitable after laboratory evaluation were sprayed or dusted on leaves of the host at various intervals, both before and after artificial inoculations.

Observations :

Symptoms of the disease : Symptoms caused by *Cercosporina ricinella* on the leaves of *Ricinus communis* have been described by Butler (1918). At first the spots appear as minute black or brown dots which soon become surrounded by a pale green ring. As they enlarge the centre turns pale brown and subsequently it becomes greyish white. The margin forms a deep brown band which may be narrow and sharp or broad and diffused. The spots are roundish in the beginning but they become irregularly angular when mature. Their size varies from $\frac{1}{2}$ m.m. to 3 m.m. or sometimes more. The spots are mostly found scattered on the leaves in great numbers. When many are close together the intervening leaf-tissues wither and develops big brown patches of dried leaf. Individual spots can still be marked out in such patches because each spot has a deep brown margin. The leaf ultimately crumples and falls off after a number of large patches are developed on it. A careful examination of the greyish white centre of the spots reveals the conidiophore clusters in the form of tiny sharp black dots.

Morphological characters of the fungus and host parasite relationship : A study of transverse sections of diseased leaf of *Ricinus communis* showed that the hyphae were septate and branched with granular protoplasm. They did not develop any haustoria and were both inter and intracellular. The conidiophores were developed in groups of 10 to 20. They were light brown in colour and were unbranched. They measured from 24 to 70$\mu \times 3$ to 6·5μ. The conidiophores were usually bent because their growth continued after the development of the conidium. The bending was evident below the attachment of the conidia. The hyphae collected to form very small stromata under the epidermis. The clusters of conidiophores emerged out through the stomata or directly from the epidermis. The conidia were elongated, tapering above and truncated below, straight or

slightly curved, colourless, divided by several (upto 7) transverse septa and measured upto 105μ in length and 4 to 6·5μ in breadth.

Pathogenicity of the fungus on the leaves of the host : The fungus was inoculated by three different methods on the young as well as old leaves of *Ricinus communis*. The results are recorded in table 1.

TABLE 1

Showing the percentage of infection on old and young leaves of *Ricinus communis* inoculated by different methods.

Method of inoculation	Surface of leaf	Condition of leaf surface	Percentage of infection Old leaves	Young leaves
1. Mass inoculation method	Upper	Injured	100	80
		Uninjured	0	0
	Lower	Injured	100	100
		Uninjured	0	0
2. Spore suspension method	Upper	Injured	70	60
		Uninjured	0	0
	Lower	Injured	90	80
		Uninjured	0	0
3. Germinating spore suspension method	Upper	Injured	90	80
		Uninjured	0	0
	Lower	Injured	90	80
		Uninjured	0	0

It is clear from the table that all the three methods were effective but the first method, *i.e.*, mass inoculation method appeared to be more suitable than the other two. The older leaves were found to be more susceptible to the disease than the younger ones as the percentage infection of the former was generally greater. Occasionally younger leaves were as susceptible to the disease as the older ones but they were never more susceptible. It appears that the tissues loose their resistance with age. The lower as well as upper surfaces of the leaves were infected only when they were injured. A comparison of the percentage of infection on lower and upper surfaces of leaves showed that in general it was more on the lower surface than on the upper one.

The organism was also inoculated on petiole, stem and the fruit of *Ricinus communis* but it could not infect any of these parts.

Cross inoculations : In order to find out if the present organism could attack other hosts, which have been reported to be infected by various species of *Cercosporina*, inoculations were made on the leaves of *Glycine soja*, *Mimosa pudica* and *Datura* sp. It was found that this organism could not infect leaves or other parts of any of those plants.

Leaves of certain other plants of Euphorbiaceae family (*viz.*, *Phyllanthus emblica*, *Croton sparsiflorus*, *Acalypha indica*, *Jatropha gossypifolia* and *Euphorbia dracunculoides*) were also inoculated but they did not develop the infection. It is thus clear

that the organism is incapable of attacking other plants infected by other species of *Cercosporina* and it cannot infect other genera of the host family.

Study of spores : A detailed study of the spores may throw some light on the pathogenicity because they are the principal agents for the dispersal and carry over of the disease.

The longevity of spores of *Cercoporina ricinella* was determined by noting the percentage germination of spores taken from diseased leaves and soil containing such leaves stored at room temperature at different intervals of time. The spores on leaves were found to be viable upto 6 to 7 months only while those from the soil survived upto 9 months.

Generally the spores of *Cercosporina ricinella* germinated by giving rise to a small swelling near the septa in the middle or lower cells. The swelling enlarged and gave rise to a small germ tube which in turn developed a branched and septate mycelium. Occasionally the germination could start from any other cell also. Germ tube appeared within 2–4 hours.

It was observed that the spores could germinate in nutrient solution containing all the ingredients of Asthana and Hawker's medium A* as well as in solutions lacking any of them. The removal of any of the essential elements (carbon, nitrogen, phosphorus and sulphur) decreased the percentage germination of the spores. The decrease was more pronounced when carbon and nitrogen were lacking. The spores could also germinate in fresh or boiled leaf extracts as well as in distilled water. It was observed that the germination percentage decreased as the concentration of the leaf extract was lowered. This decrease was more pronounced when it was diluted more than three times. The percentage germination under different nutritional conditions was as follows : Asthana and Hawker's medium A – 76%, A. H. medium without carbon – 53%, A. H. medium without nitrogen – 60%, A. H. medium without phosphorus – 70%, A. H. medium without sulphur – 71%, Fresh leaf extract – 71% and Boilded-leaf extract – 68%.

It was observed that the spore germination of the present fungus was best at 30°C. The temperatures 5°C, 10°C, and 40°C were not suitable for germination of the spores. The percentage spore germination was not significantly different at 25°C and 30°C. It was also noted that the thermal death point determined on the basis of exposure for 2 minutes was 53°C. Larger exposures of 5 minutes killed the fungus at 50°C.

Source of infection : Observations were also made in fields during the course of the present study. It was found that the diseased leaves fell to the ground and were burried in the soil. The spores on those leaves served as source of new infection. The spores isolated from the soil at different periods were found to be capable of causing the infection and this confirmed that such spores were responsible for causing fresh infections. The diseased leaves attached to the plants also served as inoculum for the spread of the disease because spores from such areas were found to remain viable for 7 months.

The mode of penetration of the parasite into the host was studied with the help of microtomed sections as well as by the method described by Petersen (1956) according to which impressions of the surface of the host leaf are taken on a thin layer of collodion. It was found that the entry of the mycelium of *Cercosporina ricinella* was only through the injured tissues. The germ tubes were incapable of entering the stomata or piercing through the epidermal cells.

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*Glucose 5·0 g., KNO_3 3·5 g., KH_2PO_4 1·75 g., $MgSO_4 \cdot 7H_2O$ 0·75 g., Distilled water 1 l.

Control of the disease : The evaluation of the following fungicides was carried out in the laboratory :

Tillex (ethyl mercury chloride), Cuprovit (basic copper chloride), Copper sandoz (cuprous oxide), Zerlate (zinc dimethyldithiocarbamate), Dithane Z-78 (zinc ethylenebisdithiocarbamate), Spergon (tetrachloro-p-benzoquinone), Agrosan (tolymercury acetate), Ceresan (N-ethylmercuri-p-toluenesulfonanilide), Isothan Q-15 (2- dodecylisoquinolinium bromide), U. N. R. 50% (alkyl dimethyl benzyl ammonium chloride), Onyxide (mixture of alkenyl dimethyl ethyl bromides) and Bordeaux mixture (3 : 3 : 50).

Various concentrations of the above fungicides were tried and only the following were successful :

Tillex (0·1%), Spergon (0·1%), Agrosan (0·1%), Ceresan (0·1%), and U. N. R. 0·1%).

Those fungicides which were effective under laboratory conditions were used for field trials. The minimum effective concentrations of the fungicides were sprayed or dusted on the leaves of *Ricinus communis* at various intervals, both before and after artificial inoculations. The results are summarized in Table 2.

TABLE 2

Showing the effect of the application of various fungicides on leaves of *Ricinus communis* inoculated with *Cercosporina ricinella*. ('+' denotes appearance and '—' denotes absence of the disease).

Time of inoculation	Fungicides applied				
	Tillex 0·1%	Spergon 0·1%	Agrosan 0·1%	Ceresan 0·1%	U. N. R. 0·1%
1. Just after application	–	–	–	–	–
2. One day ,, ,,	–	–	–	–	–
3. Two days ,, ,,	–	–	–	+	–
4. Three ,, ,, ,,	–	+	+	+	+
5. Four ,, ,, ,,	+	+	+	+	+
6. One week ,, ,,	+	+	+	+	+
7. Just before ,,	–	–	–	–	–
8. One day ,, ,,	–	–	–	–	–
9. Two days ,, ,,	–	–	–	–	–
10. Three ,, ,, ,,	–	+	+	+	+
11. Four ,, ,, ,,	+	+	+	+	+
12. One week ,, ,,	+	+	+	+	+

It is clear from the above table that 0·1% Spergon, Agrosan, and U. N. R. could check the spread of the disease, provided the inoculum had not fallen on the host earlier than two days before applying the fungicides or more than two days after application. Tillex was more effective than those mentioned above as it checked the disease even when the inoculum had fallen three days before or after the application of the fungicides. When inoculations were made two days

after the application of 0·1% Ceresan, the symptoms of the disease appeared showing that this fungicide could not check the spread of the disease when the inoculum fell on the third day of application. Thus Ceresan proved to be least effective for controlling the disease in the fields. Repeated applications of Agrosan, Spergon or U. N. R. were found to be necessary for controlling this disease. Besides this the present study also indicated that the following hygienic precautions were essential :

(1) All the diseased leaves fallen on the ground should be collected and destroyed by burning.

(2) The diseased leaves attached to the plants should be removed and destroyed.

Summary :

Pathogenicity of *Cercosporina ricinella* was established on the leaves of *Ricinus communis*. Cross inoculations were made on the leaves and other parts of *Glycine soja*, *Mimosa pudica*, *Datura* sp., *Phyllanthus* sp., *Croton sparsiflora*, *Acalypha indica*, *Jatropha* sp., and *Euphorbia* sp., but *Cercosporina ricinella* could not infect them. A number of fungicides *viz.*, Tillex, Cuprovit, Copper sandoz, Zerlate, Dithane Z-78, Spergon, Zinc sulphate, Agrosan, Ceresan, Isothan Q-15, U. N. R. 50%, Onyxide and Bordeaux mixture (3 : 3 : 50) were evaluated in the laboratory. Suitable concentrations of the effective ones were tried in the field conditions to check the disease. Repeated applications of 0·1% Spergon, Agrosan, U. N. R. 50% and Tillex could check the disease.

Acknowledgments :

The authors are grateful to Dr. R. S. Mathur, Plant Pathologist, U. P. Government for supplying the fungicides and to Dr. K. S. Bilgrami for his help at various occasions. The junior author is indebted to the Ministry of Scientific Research and Cultural Affairs, Government of India, for the award of Research Training Scholarship.

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*Originals not seen.

INVESTIGATIONS ON THE PHYSIOLOGY OF JUTE. VII—EFFECT OF DIFFERENT SYNTHETIC HORMONES ON GROWTH AND DEVELOPMENT OF JUTE

By

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[Received on April 8, 1962]

Introduction :

In jute, the fibre of commerce is laid in the stem during the process of vegetative growth which takes place by the activity of apical meristem increasing the length of the stem, followed by the transverse growth through the cambium activity, which increase the thickness of the stem. The yield of fibre, therefore, is correlated with increase in height and basal diameter and is dependent upon many external and internal factors. Investigations conducted at this Institute (Kar and De Sarkar, 1954, 1957, Kar, 1959, 1961) have revealed that the external manifestation of growth in height and basal diameter is not a true indication of fibre yielding potentiality of a variety but internal structures like fibre-wedges, fibre-strands per wedge and ultimate fibre-cells per strand, which constitute the fibre-complex determining the yield of fibre (Kar and De Sarkar 1962).

Workers on hormones (Beal 1945, 1946, Mitchell 1940, Swanson 1946, Skoog, 1951) and others have shown the effect of different hormones on the vegetative and reproductive stages of the plants and the effects on cambial activity which result in differentiation of phloem and xylem. It was, therefore, planned to investigate the induced effects, brought about by the action of hormones on the growth processes in jute, thereby resulting in the increased fibre yield.

Experimental :

Corchorus capsularis var. JRC 212 was sown in eight replications of plot size 5 × 7 ft. in lines. After necessary cultural operations, and when the plants were of one month age, they were sprayed with the following hormones—Indolyl acetic acid (IAA), Indolyl butyric acid (IBA), Indolyl propionic acid (IPA) and Napthalene acetic acid (NAA) in concentrations of 500 ppm. and 1000 ppm. by means of a sprayer. The shoot portion and the leaves were thoroughly wetted and the spraying was done twice after an interval of ten days. Equal number of plots were kept as control *i.e.* without any spray.

The following records were taken—(1) Periodic growth measurements of the stem in height and base diameter in ten randomised selected plants in each replication. (2) The incidence of flowering time. (3) At the time of harvest, the green weight of the ten plants and their dry weights of bark and wood after laboratory drying. (4) The portion of the stem where maximum growth curvature occurred was preserved for taking transverse sections to estimate the internal components of fibre-complex *e.g.* fibre-wedges, fibre-strands per wedge and ultimate fibre-cells per wedge. (5) The plots were harvested to record the yield after due retting.

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Results :

The above estimations indicated an increase in fibre wt., wood wt., green wt., height and basal diameter, thereby showing stimulated growth as a result of the different hormone treatments. The investigations further indicated differential effects and the percentage increase in fibre weight was found to be highest in IPA followed closely by NAA when compared to the control.

TABLE 1

Effect of spraying with different hormones on JRC 212.
(Average of 10 plants)

Treatments	Fibre wt. per plant in gms.	Dr. stick wt. per plant in gms.	Green wt. in gm.	Ph. in inches	Basal diameter in cm.	% increase in fibre wt.
IAA	17·013	37·60	357·80	106·10	2·325	107·161
IPA	22·534	51·30	488·60	110·20	2·660	141·937
IBA	17·415	39·60	377·51	96·60	2·680	109·693
NAA	21·887	46·25	455·00	102·70	2·715	137·862
Control	15·875	33·80	321·05	105·30	2·240	100·00
S. E.	1·47	3·63	36·2			
C. D. at 5%	4·15	10·26	102·3			
C. D. at 1%	5·52					

The statistical analysis also showed the effects on fibre weight to be significant at 1% level and those of green weights and stick weights to be significant at 5% level. It was mentioned before that as a result of hormone spray on the shoots, the apical portion of the stem showed marked growth curvature, immediately after treatment. The curvature persisted for 3–4 hours but recovered later on. When the shoot began to grow again, traces of curvature were left showing the after effects of the hormone treatment. The vigorous growth in the curvature portion of the stem was further analysed in series of transverse sections to estimate the different internal growth structures which constitute the fibre-complex in jute.

Effect on the internal growth components :

It was found that the number of fibre-wedges, fibre-strands (bundles) per wedge and the total number of ultimate fibre-cells were appreciably increased. The results have been summarized as in inset below.

Treatment	Total No. of fibres	Total No. of fibre-strands	Total No. of ultimate fibre-cells
IAA	67	43·30	16·80
IPA	71	52·80	19·84
IBA	68	45·90	16·08
NAA	—	49·06	16·63
Control	61	32.33	15·34

The above results showed clearly the stimulated effects of hormones on the cambium activity which resulted in the formation of xylem and phloem, and indirectly affected the fibre yield in jute, by increasing the different constituents of the fibre-complex.

Conclusion :

The effects of hormones indicated a possibility of increasing the yield of fibre in jute by hormone treatments. All round stimulation and especially the increased cambium activity affecting the internal growth components which determine the fibre yield, may become of great economic importance.

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A NEW SPECIES OF *CURVULARIA* ON THE LEAVES OF *DAHLIA VARIABILIS*

By

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[Received on June 18, 1962]

The plants of *Dahlia variabilis* growing in various gardens at Allahabad, manifested severe leaf spots of dark brown colour in January, 1962. The infection was either marginal or from the tips. The marginal lesions were usually vein limited. Thin dark brown zonate layers were distinctly perceptible in the diseased regions by the end of February (plate I fig. 1). By the first week of April, the infected portions got gradually detached in small fragments. Isolations from the diseased regions consistently resulted in a peculiar species of *Curvularia* with prominently distinguishable spines over the conidial walls (plate I, fig. 2). The organism produces slate gray colonies in culture. It sporulates abundantly on Asthana and Hawker's medium A and makes vigorous vegetative growth on P. D. A.

Recently Tandon and Bilgrami (1962) reported a new species of *Curvularia viz., C. verruculosa* which was similar to *C. trifolii* in configuration but different from that organism in conidial dimensions and nature of the conidial wall which was rough and verruculose. The morphological characters of the present species markedly differed from all the known species due to presence of distinct spines over the conidial walls and it is, therefore, being designated as *Curvularia spinosa*, sp. nov.

Morphological characte rs of the fungus :

Curvularia spinosa, sp. nov.—Conidiophores simple, unbranched, septate, geniculate at the tip, 7·0–8·3μ broad, variable in length ; conidia produced in spiral manner towards the tip of the conidiophore, young conidia light brown, smooth walled, cylindrical or slightly curved, usually three septate, 20–26$\times$7–10μ ; mature conidia dark brown, with distinct spines, (2·5–3μ long) over the entire wall, few blunt hyaline processes may also be produced over the wall, (plate I fig. 3), generally three septate, two middle cells darker in colour than the basal or the apical cell, may be oval or curved, 21–36$\times$9–15μ (average 27$\times$12μ), second cell from the base is slightly broader and curved ; some of the conidia are spindle shaped, 30–49·5$\times$9–12μ, average 42$\times$9 5μ (plate I, fig. 4) or two celled measuring 9–18$\times$6–9μ (average 15·5$\times$7·4μ). Rarely the conidia may be six celled also, measuring 38–45 $\times$ 10–12μ (average 42$\times$11μ).

Latin Translation :

Curvularia spinosa sp. nov.—Conidiophori simplices, haud ramosi, septati, geniculati ad apices 7·0–8·3μ lati, longitudinis variae ; conidia producta spiraliter ad apices conidiophororum, juvenilia quidem pallide brunnea, parietibus levibus, cylindrica vel paulum curvata, vulgo ter septata, 20–26$\times$7–10μ ; matura vero fusce burunnea spinis distinctis ornata per totos parietes, vulgo ter septata, cellulis binis mediis fuscioribus, ovalibus vel curvatis 21–36$\times$9–15μ (mediet 27$\times$12μ) cellula secunda e basi paulo latiore et curvata ; conidia nonnulla fusiformia,

PLATE I

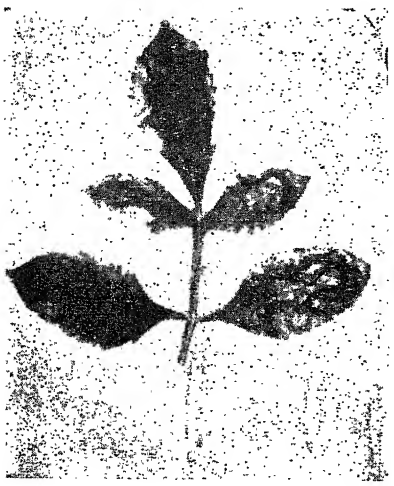

Fig. 1. Showing the infection on leaves of *Dahlia variabilis*.

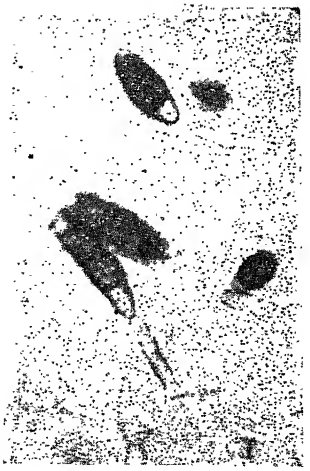

Fig. 2. Microphotograph of *C. spinosa* showing distinct spines over the wall of conidia (×600).

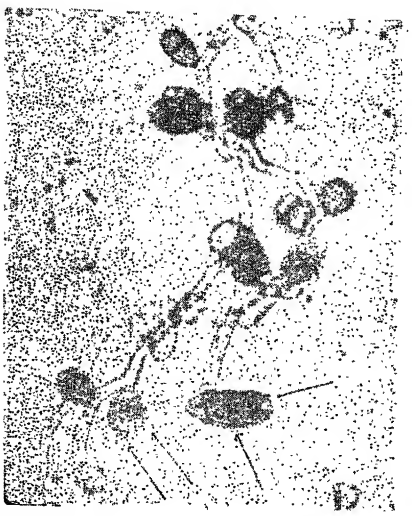

Fig. 3. Microphotograph showing blunt hyaline processes over the conidia (×600).

Fig. 4. Microphotograph showing the spindle shaped and elongated conidia (×600).

30–49·5 × 9–12μ (mediet 42 × 9·5μ), raro sex-cellularia, 38–45 × 10–12μ (mediet 42 × 11μ) vel bicellularia 9–18 × 6–9μ (mediet 15·5 × μ7·4).

Parasitice insidet foliis *Dahliae variabilis*. Cultura posita in sectione mycologica universitatis Allahabadensis.

The present species differs from all the known species of *Curvularia* in having (*i*) uniform spines and blunt hyaline processes over the wall, (*ii*) very variable shape and size of the conidia which do not agree with any of the existing species.

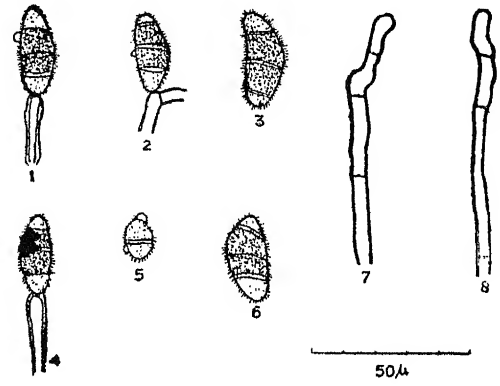

Fig. 5. Camera-lucida drawing of conidia (1—6) and conidiophores.

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The authors are grateful to Professor R. N. Tandon, Head of the Botany Department for providing laboratory facilities and to Professor H. Santapau for the Latin translation.

Reference :

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A NOTE ON THE MINERAL STATUS OF FIVE TREE SPECIES, GROWING AT RAIPUR, AS A FACTOR IN COMMUNITY COMPOSITION

By

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Plants of a species are grouped into populations and populations of different species are intermingled to form a plant community. Why should species intermingle ?—is the obvious question. The demands of a plant upon environment are according to its genetic pattern and physiology. It would appear that species with similar demands should form a community or species coming under a certain range of tolerance may grow together. It was to give some basis to this assumption that the present study was undertaken. Five tree species were chosen to evaluate their chemical status under similar conditions of climate, soil and biotic factors.

According to Gilbert (1950) the proportion of an element in the ash is not an absolute indication of its relative value to the plant but it usually indicates the bases avilable to the plant from the soil. However, if the quantity of exchangeable bases from the soil and their respective proportion in the parts of the overlying plants are analysed, it may reveal to some extent the chemical requirements of plants.

In view of this the five tree species were chemically analysed together with the respective soils. The study was undertaken at Raipur (M. P.). For the uniformity of the results those dominant species were chosen which are growing together in a small patch of forest situated near Science College Campus.

Situation, Climate and Geology of Raipur :

Raipur is situated at 21°15' North Latitude and 18°37' East Longitude and is 310 m. above sea level. It is on almost flat topography.

The climate of Raipur is periodic. The average annual rainfall is about 1,270 mm. The monsoon months are June to September when about 1,100 mm. of rains are obtained ; July and August are wettest months. The mean maximum temperature during the period is 31·50°C and the mean minimum is 25·4°C. This is followed by winters lasting for about 3 months when the days are cold and bright with 27·5°C and 13·5°C as mean maximum and minimum temperatures, respectively. The rainfall during this period is about 80 mm. The month of March is a mild warm period of transition between cold and the following hot season. Summers extend from April to middle of June, when the mean maximum temperature goes upto 42·1°C. However, an absolute temperature of 47·5°C may sometimes be experienced in the month of May. (The climatic data were recorded by the authors during 1959-60).

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The geological formation of the area is Cuddapah series consisting of varieties of stones like, sandstones, shales, shaly limestones, schists and other sedimentry rocks. At Raipur and especially where the forest under examination is situated, shaly limestones form the underlying lithology.

Material and Method :

The species chosen for the study are :

Tectona grandis Linn.

Terminalia tomentosa W. & A.

Chloroxylon swietenia DC.

Gardenia latifolia Ait, and

Holarrhena antidysenterica Wall.

Ten samples each of young mature and dried leaves (litter) of the five tree species were separately collected in the month of September and again in October, 1959. The trees were marked and care was taken so that the whole forest is covered in sampling. The samples were analysed for ash, silica, calcium and sesquioxides as per the methods outlined by Piper (1947).

Corresponding number of soil samples were also collected from a depth of 15 cm. and analysed as per the methods given by Misra (1944) for : moisture ; pH value ; nitrates ; base deficiency ; and exchangeable calcium (*cf.* Piper, 1947).

The Vegetation :

The vegetation of Raipur is mixed forests with or without teak (*Tectona grandis*). However, very little of the forests have been left now due to cultivation and frequent grazing.

The patch of the forest under examination is lunar shaped running north-east to south-west and covering an area of about 2·5 sq. km. The forest was examined by belt transects for its phytosociological analysis. However, it will be out of scope of this paper to give the details of the same here. The dominating species of the forest are the ones chosen for the present study.

Presentation of Data :

Average values of foliar analysis of the five species and composition of the soils are presented in table 1.

A—Foliar analysis.—Remarkable variations are found in the five species with respect to the elements examined. Further, variations are also noted in the different age groups of leaves within the species.

Intercomparing the various elements in the different species, only in mature leaves samples, the following observations are made :

(*i*) Ash varies from 5·98% (in *Chloroxylon swietenia*) to 14·447% (in *Gardenia latifolia*). The ash content progressively increases with age ; as also shown by Jain (1960) and Joshi (1959) in *Shorea robusta* Gaertn. f. and *Anogeissus latifolia* Wall., respectively.

(*ii*) Silica content does not behave corresponding to the ash %. It is recorded highest in *Tectona grandis* (being, 2·9154%) and lowest in *Chloroxylon swietenia.* It also increases with age.

(*iii*) Foliar calcium is more or less related to the ash content in the sense that it is lowest in *Chloroxylon swietenia* and highest in *Gardenia latifolia* (being,

0·2918 and 1·3884%, respectively). However, calcium decreases again in litters showing that some part of the minerals are returned to the plant at the time of leaf-fall.

(*iv*) Sesquioxides behave much parallel to foliar calcium as far as its variation with age is concerned. Sesquioxides are lowest in *Terminalia tomentosa* (1·1672%) and highest in *Holarrhena antidysenterica* (1·6464). Large variations are therefore, not found with respect to this element.

Concluding the foliar analysis it is noted *Tectona grandis* leaf-litter is rich in silica content and may take more time to decompose in comparison to the remaining four species.

TABLE I

Foliar analysis of 5 tree species and the composition of the respective soil samples (values, expressed as percentage of dry wt., are averages of 10 samples).

A—FOLIAR ANALYSIS Date : September–October, 1959

Species	Samples of :	Ash	Silica	Calcium	Sesqui-oxides
Tectona grandis Linn.	(*a*) Young leaves	4·8378	0·8607	0·2066	0·6935
	(*b*) Mature leaves	6·5868	2·9154	0·3685	1·6464
	(*c*) Leaf-litter	10·8920	3·8908	0·1500	3·0094
Terminalia tomentosa W. & A.	(*a*) Young leaves	7·1358	0·2937	0·5200	0·9945
	(*b*) Mature leaves	7·4721	1·5311	0·5904	1 1672
Chloroxylon swietenia D. C.	(*a*) Young leaves	4·8920	0·2754	0·1278	0·9140
	(*b*) Mature leaves	5·9800	0·2925	0·2918	1·2158
Gardenia latifolia Ait.	(*a*) Young leaves	10·9529	0·4185	0·4556	0·3516
	(*b*) Mature leaves	14·4470	0·8594	1·3884	1·3526
	(*c*) Leaf-litter	28·7700	0·9364	0·64403	0·4983
Holarrhena antidysenterica Wall.	(*a*) Young leaves	6·8348	0·6573	0·3372	1·0976
	(*b*) Mature leaves	8·0137	1·2091	0·7806	1·0862
	(*c*) Leaf-litter	8·4240	1·4572	0·3683	1·9523

B—SOIL ANALYSIS : Date : 6th September, 1959

Samples	Water content	pH-value	Nitrates in Scale of 1–5	Base deficiency in Scale of 1–5	Exch. Calcium
Soils from 15 cm.	14·725	6·27	2	1	0·0398

B—Soil analysis.—Remarkable variations were not found in the composition of the soils examined. Therfore, only the summary values for all the samples are given in table 1.

The soils are near neutral (pH-6·25) and moderately rich in exchangeable calcium and nitrates. It may be noted that the exchangeable calcium is only 0·0399%, inspite of shaly limestones as the underlying rock. This may be due to the litter contents of the dominant species. Table 1 will show that very little of calcium is returned to the soil through litter.

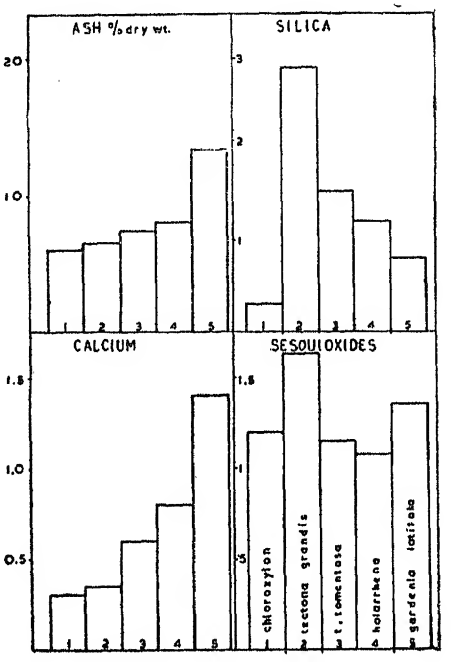

Fig. 1. Foliar contents of the five tree species, growing at Raipur ; expressed as percentage of dry weight.

Discussion :

Table 1 and text-figure 1 show the variations in the mineral elements present in the five dominant tree species of the forest examined. All the species are rich in mineral elements.

It may be pointed out here that *Tectona grandis* is gradually dwindling from the patch of the forest, as is evident from the absence of its saplings in the floor. This may not be due to climatic or soil factors. Actually Bhatia (1958) has observed that *Tectona grandis* is a heavy demander of bases especially calcium. In light of this, and the area being not poor of soil exchangeable calcium, edaphic factor may not be the cause of gradual lessening of *Tectona grandis* from the forest. It was mentioned previously that the forest is under anthropogenic influence which may be a factor in the phenomenon.

Coming to the mineral status of the five species remarkable differences have been noted between them. Even then the species grow together. It appears that species are blend together because every species has a certain range of requirements (or range of tolerance) and the species grow together in a habitat which comes under a point of common range.

Summary :

The present study was undertaken to ascertain whether species with similar demands should form a community or species coming under a certain range of tolerance may grow together.

With the help of foliar (of 5 tree species) and soil analysis it has been shown that species grow together in a habitat which comes under a point of common range of requirements.

The studies were made at Raipur (M. P.)

Acknowledgment :

We are thankful to Dr. Karam Singh, Principal, Science College, Raipur, for the necessary facilities.

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DIFFERENTIAL REQUIREMENT OF LIGHT-LOVING AND LIGHT-AVOIDING PARTS OF PLANTS WITH RESPECT TO BORON

By

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Introduction :

The role of micronutrients in shaping the destiny of plants through the control of their metabolic potentiality stands accepted. It is now held that all the generally recognised trace elements, with the possible exception of boron, either form an integral part of certain enzymes or activate enzyme systems. Boron has been treated by Ellis and Swaney (1938) as a hormone and that it has to be supplied from extraneous sources.

The precise role that boron plays in the growth and development of plants, more so, of the light-loving (shoot) and light-avoiding (root) organs has remained obscure.

Speculations about the role of boron in plant metabolism first took birth with the discovery of boron as boric acid in the seeds of *Maesa picta* by Wittstein and Apoiger (1857). Adequate supply of boron is considered essential for the proper development of the vascular system in the roots, for supply of carbohydrates to the nodules in the leguminous plants (Thornton, 1925) and for the proper functioning of the meristematic tissues (Singh and Chadha, 1963).

Although considerable work has been done on the role of boron in plant nutrition, the causes leading to its differential need for the root and the shoot remains to be settled.

Materials and Methods :

Seeds of *Cajanus cajan* (Type 1) were kept in dark over moistened filter papers for germination. Soon after the emergence of the radicle, seeds were transferred to polythene containers with 740 gms of silica sand washed after the method recommended by Hewitt (1947). The plants were kept in shade and received diffused day light throughout the period of experimentation.

The effect of boron supply was evaluated with 4 concentrations *viz.*, (1) no boron supply (–B), (2) complete nutrient (Arnon, 1938) with 0·01 ppm of boron (Bn), (3) 1·25 ppm of boron (Ba) (in addition to treatment designated in (1) above), and (4) 2·5 ppm of boron (Bb), in addition to treatment designated in (1) above. The boron deficient solution that formed the basic supply of nutrients was given six times during the period of study. Distilled water in the boron-free series and the requisite amount of boron in other series were added on alternate days on seven occasions.

Treatment effect was noted after the plants had attained the age of 20 days, the readings being taken every week. Attributes of growth *viz.*, number of roots, length of roots, height of stem, and fresh as well as dry weight of both the roots and shoots were recorded. These shoots and roots were analysed with respect to

sugars, chromatographically. The extraction procedure followed for the chromatographic assay of sugars was that of Steward *et al.* (1954).

Circular paper chromatographic technique as modified in these laboratories (Ranjan *et al.*, 1955) was followed for the separation and identification of sugars. The chromatogram was developed by spraying the aniline-diphenylamine phosphate reagent (Buchan and Savage, 1952) and then drying the chromatograms for ten minutes at 80°C. For quantitative estimation of individual sugars, elution was done, solution prepared, and sugar estimated after the method of Somogyi (1945).

The Results :

Branching behaviour :

Shoot.—No branching was observed in any of the replicates under any of the treatments (Plate 1).

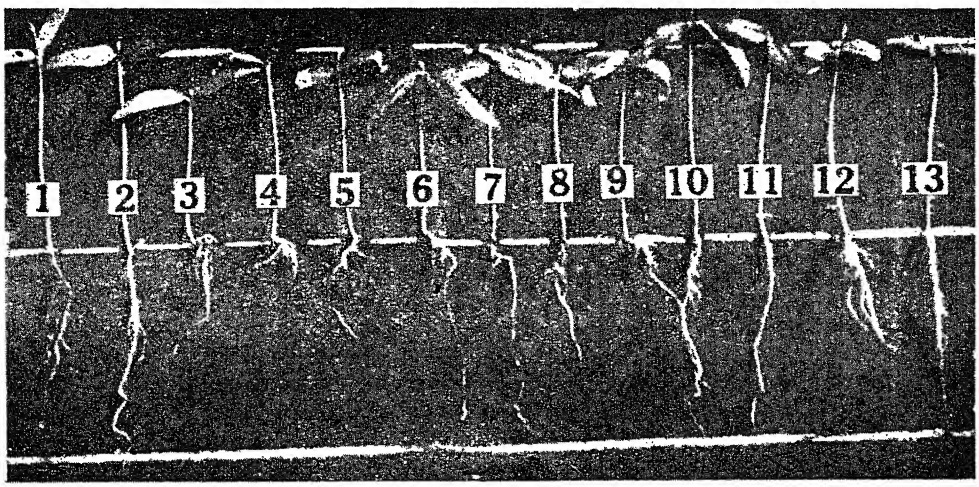

PLATE 1. Effect of varying levels of micronutrient supply on the growth of *Cajanus cajan* at 34-day age. 1 : Ba, 2 : Bb, 3 : —B, 4 ; Zna, 5 ; Znb, 6 ; —Zn, 7 ; Mna, 8 ; Mnb, 9 ; Mn, 10 ; Moa, 11 ; Mob, 12 ; —Mo, 13 ; control.

Root.—The no-boron series possessed maximum number of roots, signifying greater ramification, at all the stages ; the number declined progressively as the concentration of boron increased (Table 1).

TABLE 1

The effect of levels of boron supply on the extent of branching
(Average no./plant)

Age (days)	Levels of supply			
	—B	Bn	Ba	Bb
20	19·66	17·00	9·66	1·00
27	28·66	18·30	16·00	15·33
34	26·66	22·25	19·33	15·50
41	26·00	24·30	21·00	17·50

The formation of roots increased with age in all the treatments except in the boron deficient series where the root number decreased after the 27–day age signifying that, under the conditions, the insufficiency of the element became more pronounced with age. The maximum average increase of 3·8 in the root number of Bn series (normal supply of boron) was registered between 27 to 34 days while the increase of 9·0 in the Bn, 6·33 in Ba and 14·33 in the Bb series was recorded during the 20–27 day period. The variations in the number of root at the different stages after the 27–day age were not significant as compared to the maximum increase reported earlier under any of the treatments.

Linear growth :

Shoot—Supra supply af boron proved deleterious for linear growth of shoots at all the stages depicting that in the matter of shoot extension also, as in the case of its dry matter, the normal level of the supply of boron proved optimum (Table 2).

With age, shoot length increased irrespective of the treatments. The magnitude of increase differed both with advance in age as well as with the level of boron supply. Maximum increase was affected by the application of boron at the normal level ; it decreased with change in supply position on either side. On an average, the trend of behaviour was very much identical to that witnessed in the case of shoot dry-matter.

TABLE 2

The effect of levels of boron supply on the linear growth of shoot
(Average, cm/plant)

Age (days)	Levels of supply			
	—B	Bn	Ba	Bb
20	6·80	8·00	5·03	3·56
27	10·20	11·66	11·40	9·90
34	10·73	12·575	12·00	10·06
41	11·30	13·025	13·00	12·05

Root—The effect of the various concentrations of boron was evident on the linear march of the main root differently. All the treatments increased root length with age. Normal supply of boron induced maximum linear growth of root closely followed by Bb level ; the treatments Ba and no-boron showed markedly less linear growth than others at the 20-day age. The effect of the treatments was slightly different with advance in age signifying that possibly with increase in age both the demand and the ability of the plants to utilize boron for the growth of the roots changed.

Increase in the levels of boron supply induced more linear growth of roots, such that in general 2·5 ppm of boron induced the maximum length and the boron-free supply the minimum at the 41-day age, this being consistently true for the preceding periods also. The controlling behaviour of boron in relation to root length was thus amply evidenced.

TABLE 3

The effect of levels of boron supply on the linear growth of root
(Average, cm/plant)

Age (days)	Levels of supply			
	—B	Bn	Ba	Bb
20	3·90	9·30	4·20	8·30
27	9·43	12·43	10·20	15·36
34	10·60	12·70	14·00	14·50
41	10·83	14·62	14·86	15·50

Albert and associate (1961) reported that withholding of boron from the nutrient solution resulted in an inhibition in root elongation within 24 hours, the finding were not in tune with the present one. The behaviour in the present case might possibly be due to the lowering of the boron requirement by raising the plants in diffused day light, a condition which was known to inhibit the development of deficiency symptoms in contrast to plants grown in full day light as suggested by Mac Vicar and Struckmeyer (1946).

Dry matter production :

Shoot—Shoot dry matter remained lower in plants supplied with supra levels of boron in comparison to those receiving normal supply. The boron deficient plants produced more dry matter at the 20 and 27 day age as against the normal supply of boron. But for this exception the normal supply proved optimum in dry matter accumulation in comparison to the other boron levels. With advance in age, the normal supply of boron augmented larger shoot dry matter (Table 4).

TABLE 4

Effect of levels of boron supply on dry matter production of shoot
(Average, gm/plant)

Age (days)	Levels of supply			
	—B	Bn	Ba	Bb
20	0·042	0·049	0·032	0·030
27	0·044	0·038	0·036	0·034
34	0·038	0·040	0·032	0·030
41	0·038	0·043	0·0326	0·0316

Root—Augmentation of root dry matter was also affected by boron supply. Plants fed on the boron deficient nutrient solution showed, invariably, lower dry matter production of roots than the boron fed plants of the concentrations tried. The rise in the concentration of boron to Ba and Bb levels though proved less effective to root weight at initial stage became increasingly effective, the Bb level proving optimum, more so with advance in age (Table 5).

TABLE 5

Effect of levels of boron supply on dry matter production of root (Average, gm/plant)

Age (days)	Levels of supply			
	–B	Bn	Ba	Bb
20	0·0042	0·0055	0·0046	0·0046
27	0·0066	0·0066	0·008	0·0083
34	0·007	0·0075	0·010	0·012
41	0·007	0·0076	0·015	0·022

Progressive increase in dry matter production of roots, with age, was registered in plants receiving higher concentrations of boron. The rate of increase in dry matter of roots in boron deficient and in normal boron supply series was shown to decline consistently with increase in age depicting greater need for boron for root growth with age. It also exhibited that high doses of boron proved benefical for the dry matter synthesis of roots with 2·5 ppm of boron as optimum. The growth behaviour of roots as evidenced by dry matter production followed a different trend of response for shoots (*Cf.* Tables 4 & 5).

Accumulation of sugars :

Shoots—Boron supply, at different levels, affected the sugar content of shoots differently. At the 27-day age boron deficient series possessed the maximum amount of reducing sugars ; the quantity decreased inversely with the supply of boron. In general, the reducing sugar content for any treatment decreased with age, exception being the control plants where the quantity of reducing sugar was maximum at the 34-day age (Table 6).

TABLE 6

The effect of levels of boron supply on the accumulation of sugars in shoot (Mean, mgm/gm)

Reducing sugars					Non-reducing sugars			
—B	Bn	Ba	Bb	Age (days)	—B	Bn	Ba	Bb
499·0	207·1	230·0	222·5	27	88·00	85·00	179·5	198·0
405·0	405·0	87·50	286·5	34	64·5	199·0	202·5	222·5
394·0	234·5	340·0	286·0	41	124·00	140·0	135·0	137·5

The 34-day stage was also different from the stages preceding and following, in the sense that at this stage the (Bb) treatment surpassed the Ba treatment in the accumulation of reducing sugars. The quantity of reducing sugars in all the boron treated plants was more than the non-reducing sugars with the sole exception of Ba treatment at the 34-day age when the reverse held true.

Non-reducing sugars in the boron supplied series increased with advance in age upto the 34th day beyond which the quantity fell down in the shoots of boron fed plants.

Roots—The percentage of reducing sugars in the roots increased in all B fed plants with age. Though on the 27th day the reducing sugars decreased with increase in supply, beyond the normal, on the 34th day no clear cut effect of the concentrations was maintained. On the 41st day the reducing sugars were almost equal irrespective of the change in boron concentration on either side of the normal (Table 7).

TABLE 7

The effect of levels of boron supply on the accumulation of sugars in roots (Mean, mgm/gm)

Reducing sugars					Non-reducing sugars			
—B	Bn	Ba	Bb	Age (days)	—B	Bn	Ba	Bb
1 650	2·700	1·012	0·675	27	traces	0·675	1·012	1·650
3·037	2·700	1·65	2·025	34	0·3375	0·3375	1·012	2·025
2·700	3·712	2·700	2·700	41	0·675	1·012	0·675	3·375

In the boron-free nutrient solution at the 34 day age, the reducing sugars was higher than the control (Bn) plants. The quantity of non-reducing sugars was less in the control, and the various concentrations than the quantity of reducing sugars except in case of Bb at the 41-day age.

Considering the total quantity of sucrose present in root at the different stages of observation it was made clear that more sucrose was available in the roots receiving higher supply of boron than those receiving the smaller quantity (Table 8).

TABLE 8

Effect of levels of boron supply on the accumulation of sucrose in roots (Average, mgm/plant)

Age (days)	Levels of supply			
	—B	Bn	Ba	Bb
27	traces	0·044	0·081	0·140
34	0·0235	0·025	0·010	0·243
41	0·047	0·076	0·101	0·742

This suggested the possibility that sucrose translocation to roots was facilitated by the higher concentrations of boron.

Discussion :

These findings are in general agreement with those of Broyer and Hoagland (1943) that micronutrients were needed for the proper functioning of the roots, as well as of Brenchley and Thornton (1925), Brenchley and Warington (1927), Haynes and Robbins (1948), Mulder (1950), Mironenka (1955), Humphries (1956), and others to the effect that boron was essential for the growth and development of roots.

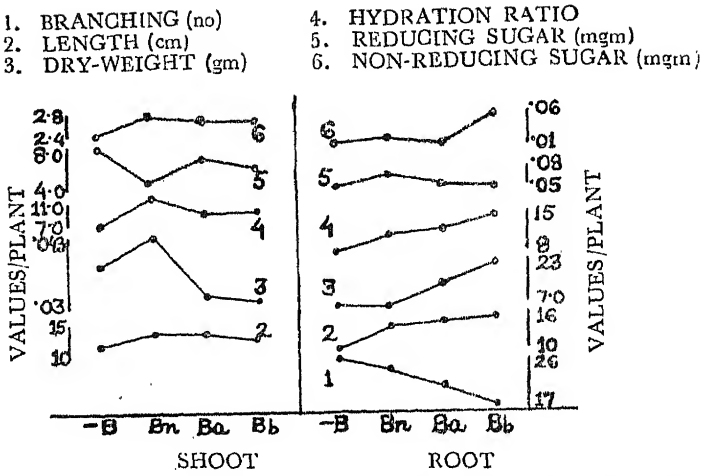

Fig. 1. Trend of performance of photo tropically different organs of the plant, with change in level of Boron supply, (41-day age).

The performance of phototropically different organs of the plant with changes in level of boron supply at the 41-day age of *Cajanus cajan* seedlings has been quite marked (Fig. 1). The Bb level of supply proved optimum for linear growth, dry matter accumulation, hydration ratio and also non-reducing sugars of the roots and deragatory to linear growth, dry matter accumulation, reducing and non-reducing sugars of the shoot. While, on an average, Bn level proved optimum for the growth of light-loving parts it did not for roots.

Withholding of boron supply from the medium of growth increased ramification of roots, though did not affect branching of shoots (Plate 1). Encouragement to ramification of root was also observed, under boron-deficient conditions by Albert and associate (1961). Supra level of boron proved optimum for the dry matter production of roots, though for shoots its normal concentration was more effective. There seemed possibility of the development of some specific substance of the type of auxin in the roots of boron deficient plants to encourage its ramification. The specific substance proved ill-conducive to root dry matter production.

The experimental evidences support Harris and Gilman (1957) who reported increased yield of *Arachis hypogea* nuts with accompanying reduction in foliage by additions of boron. It also confirmed the findings of Odhnoff (1957) who recorded a low root-shoot ratio under conditions of boron insufficiency as in these investigations the rapid dwindling down of shoot/root ratio with increase in level of Boron supply was indicated (Fig. 2). The need for boron to the plants in optimum quantities and ratios for the growth and function is remarkably clear.

Increased augmentation of root dry-matter of *Cajanus cajan* with larger supplies of boron revealed its greater demand by the light-avoiding parts of the plant. Such a behaviour though confirmed the essentiality of boron to both the light-loving as well as the light-avoiding parts of the plant, depicted a distinct variation in the level of requirement by the two parts.

The exact cause of the existence of a distinct photobiased action of boron may not be well understood at the moment but it seemed to be associated, in all likelihood, with the release of energy, the control of the action of root auxin or the two acting in unison.

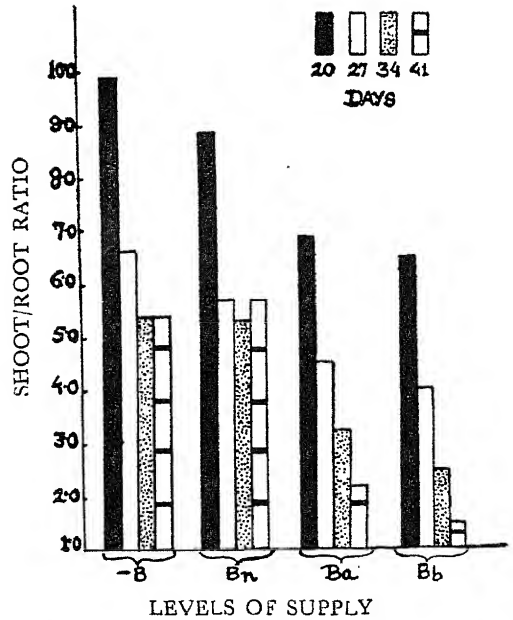

Fig. 2. The effect of levels of Boron supply on Shoot/Root ratio (per plant basis).

In the release of energy boron, presumably, played a dominant role. The existence, on an average of a higher hydration ratio in the roots as compared to the shoots (Fig. 3) suggested that more energy was produced in the former from respiration as held by Kelly (1947) which in general depended on the availability of carbohydrates in the plant organ

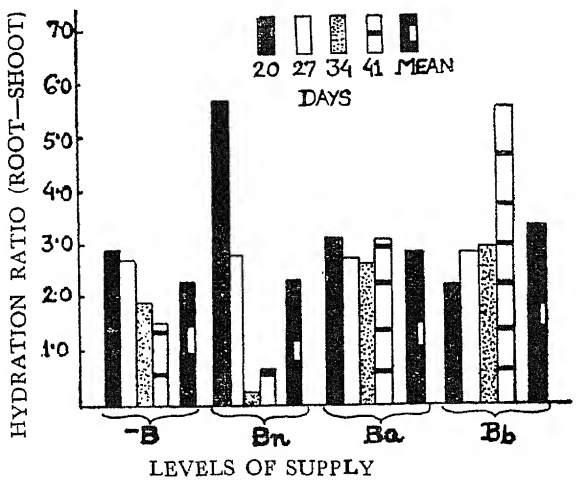

Fig. 3. Magnitude of variance in the hydration ratio (Root—Shoot) as affected by different levels of Boron supply.

The differential demand by plant parts responding differentially to photic stimuli during their growth and development was an observation unlike those of Lent and coworker (1954), Mac Vicar and Struckmeyer (1946) who concluded that the requirement of boron was lower in shorter day-length. Even after the pronouncement of the photoperiodic controlled action of boron by Warington (1933), the relationship between the element and the different organs of the same plant showing dissimilar response to light has remained obscure. Direct relationship between root growth and photosynthesis on the one hand and photosynthesis and boron requirement on the other was pointed out by Baumiester (1943), Richter and Vasiléva (1941) and Wassink (1957).

In the present investigations, conducted in diffused day light, additional supplies of boron activated the linear growth of root as well as its dry matter accumulation. Just as the behaviour of shoot and root was distinctly dissimilar with respect to their photic response and also photic requirement these positively phototropic and negatively phototropic parts of the plant behaved differentially with respect to boron especially in the matter of level of requirement. Plant shoot was known to elongate, without increase in dry weight, in the absence of light while plant roots showed ramifications without any gain in their dry weight in the absence of boron.

The probability might be examined if increased dose of boron increased the growth of roots by inhibiting the action of root retarding harmones reported to be present therein (Audus, 1959). Root auxin when present in small amount promoted root extension, though in larger doses it proved deleterious (Hansen, 1954). Larger quantities of boron might be considered to have acted in a manner similar to that produced by smaller concentrations of root auxin towards root extension. In what way did larger supplies of boron bring about increased root growth remains to be settled. It was likely that boron was essential to auxin metabolism though not concerned with its synthesis as held by Dyar and Webb (1961).

High concentrations of boron might have proved stimulatory to root growth by inactivating non-auxin inhibitors, the presence of which was reported by Audus and Thresh (1955), Kefford (1955) and Libbert (1955). The multigrowth substance system in the plants was acted upon by boron in a manner that higher doses proved optimal for the growth of light-avoiding organs of the plant and not of the light-loving ones. The effect of the increase in supply of boron (Bb level) was to increase the dry weight of the roots and a drop in that of the shoots. If the root be considered as a reservior of IAA as suggested by Cutler and Vlitos (1962) it may be presumed that there was no drop in the level of IAA as it should have brought about an increase in the growth of shoots, which it did not. It may also be possible that increased concentration of IAA increased the formation of neutral inhibitors (of shoot growth) as held by Libbert (1955) to the inhibition of shoot growth.

The possible essentiality of boron to the metabolic activity of the meristem atic regions whose relationship to translocation stands established may not be excluded. Duggar *et al* (1957) opined that boron increased translocation in plants by decreasing the enzymatic conversion of glucose-1-phosphate to starch so that increased level of soluble carbohydrates were responsible in increasing translot cation from source to sink. It is in this manner that the source to sink relationship stressed by Swanson (1957) seemed to be affected by the quantity of boron-supplied to plants.

Evidences point out, (Crafts, 1961) that sucrose was the only sugar translocated in the phloem. The total quantity of sugars in the roots increased with

increase in the level of boron supply and also of age showing that larger quantity of sugar was translocated to the roots *via* phloem with increase in boron supply level (*Cf.* Table 7) that boron played a role in the control of normal growth of both the root and shoot was well established. The difference between root and shoot behaviour with respect to boron requirement may be considered to be one of degree and not of fundamental response.

There seems to be an inverse quantitative relationship of the needs of the tops and roots for boron and light, though both seemed complimentary to the growth of the plant.

Summary :

Cajanus cajan seeds were raised in polythene containers containing 740 gms. of acid-free silica sand in shade. The effect of boron supply was evaluated in four concentrations of no supply, 0·01 ppm, 1·25 ppm, and 2·5 ppm. Treatment effect on the plants with respect to the morphological and quantitative expressions of the growth of root and shoot separately was recorded. Sugar estimation was done alongside. The need of micronutrient for proper functioning of root has been demonstrated.

Root ramification was maximum in the no-boron series at all stages though insignificantly more. Supra supply of boron proved deleterious for liner growth of shoot at all the stages depicting that both in shoot extension as well as in case of its dry matter the normal supply of boron proved optimum. Withholding of boron from nutrient solution did not result in inhibition in root elongation possibly due to the lowering of boron requirement of the plant raised in diffused day light. The root and the shoot dry matter behaved differently with different levels of the boron supply.

High doses of boron proved beneficial for dry matter synthesis of roots though not of shoots. Boron supply at the rate of 2·5 ppm proved optimum for linear growth, dry matter accumulation, hydration ratio and also non-reducing sugar of roots while deragatory to linear growth, dry matter accumulation, reducing and non-reducing sugars of the shoot. On an average the light-loving parts of the plant flourished better in normal supply of 0·01 ppm boron while the light-avoiding parts did not do so.

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ECOLOGICAL PERSPECTIVE ON GRASSLANDS

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Introduction :

Grassland creation, stabilisation and conversion to forest or desert depend on biotic factor complex of grazing animal, fire, shifting cultivation and regional land use. It may be said that "while man is striving to maintain grassland, nature is striving towards development of forest" (Davis 1954). Whyte (1957) maintains that there are hardly any artificial grasslands in India, certainly none in the forest, but existing grasslands are not wholly natural either. Increasing attention is paid now-a-days for understading the role of grasses in soil conservation and desert control (Rege 1959, Singh 1959). Topics such as grassland types, grassland soils, subterranean organisation, root productivity of grasses, grass and legumes and role of grazing animals are described in this perspective for better understanding of grassland species and their environs.

Grasslands :

Grasslands in India are seral communities in evergreen and deciduous forest lands. Desert areas also support grasses with a sparse population of low growing trees. Whyte (1957) has classified grasslands of India into eight types. These grasslands owe their origin and development to a number of factors of which biotic and edaphic play decisive role (Ramam 1960). Grasslands are designated as biotic communities in plains devoid of tree growth. Deforested areas in hills support tall grasses. These are known as Savanna grasslands. The organisation of *Dichanthium* grassland and *Phragmites/Saccharum* grassland type studied by the authors, are dealt here briefly.

Dichanthium/Cenchrus/Elyonurus type is found in arid and semi-arid tracts with 75 cm. of annual precipitation. *Sehima/Dichanthium* type presents optimum development under rainfall of 60–90 cm. ; this type seems to extend widely over tropical India comprising Deccan Plateau and further covers south Bihar and eastern parts of West Bengal. Management of this grassland type is possible with growth of *Sehima nervosum* on gravelly soils in the hilly parts and those of *Dichanthium annuulatum* on level moist habitats (Dabadghao 1957). In relatively humid eastern wing of Upper Gangetic plain with 92 cm. of rainfall, *Dichanthium/Bothriochloa* grassland type is wide spread on alluvial plains (Ramam 1960*a*). In this region continuity of fodder supply is possible from the herbage of *Bothriochloa pertusa* in the monsoon and that of *Dichanthium* in the post-monsoon dry period.

Phragmites/Saccharum grassland type occurs in high rainfall areas, preferably on low lying ill-drained habitats as seen in Assam, Manipur states and Western parts of Uttar Pradesh. In the hilly areas of Varanasi district, senior author (Ramam 1960*a*) reported the role of soil moisture in segregation of grasslands on xeric and mesic habitats where *Vetiveria* grassland complex spreads over wet habitats devoid of trees along river courses. Verma (1961) records *Saccharum munja* grassland on sandy forest habitats subjected to inundation during rains. Similar

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grassland occurs on sandy to sandy clay soils bordering 'Sal' forests at Ganauli in north Bihar. This forest belt has annual precipitation of 125–160 cm. where the grassland is of progressive pattern as in Chart I. The knowledge gained so far from the grasslands of Champaran forests in north Bihar suggests revision of *Phragmites/Saccharum* grassland type as designated by Whyte (1957).

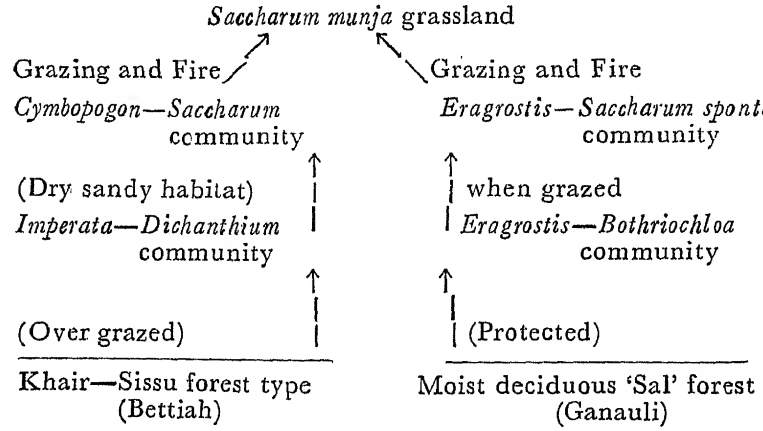

Chart I—Progressive pattern of Champaran forest grasslands in north Bihar

Grass and Legumes :

Grass is treated as a crop in England now-a-days. It is often said that "two blades of grass are now grown where only one before" (Davis 1954). There is great potential for development and improvement of tropical and sub-tropical pastures based on sound scientific methods evolved in temperate climates where grass and legume mixtures are tried for soil fertility and higher herbage yields.

Nodulated roots are present in most of the legumes. The nodules, after the death of the plant, decay and enrich the soil with organic nitrogen and Vitamin B_{12} (Activity of Rhizobium). White clover is found to enrich the grassland soils with nitrogen equivalent to approximately 500 kg/ha nitrate of lime (Bean 1960). Natural pastures in tropical and sub-tropical regions are poor in proteins and nutrients. Soils of India are poor in fertility. Legumes can help to enrich the soil whereby pastures can be grown on nitrogen poor soils.

A world wide search is there for legumes and adaptability of these species for local conditions. Radiation and breeding trials in legumes are attempted in Australia, South America and Indonesia. Especially the genera *Desmodium* and *Indigofera* contained 600 to 900 species respectively. Among these, there is a possibility of mixtures of various races to suit ecoclimes of regions interested to introduce them. *Indigofera spicata* is found very promising in Australia, but it contains toxin poisonous to cattle. Radiation has been used to induce mutants low in the toxin. *Lotononis bainesii* is the other legume, from the mountains of South Africa, introduced into Australia. Other legumes being tried in Australia are *Phaseolus atropurpureus, Medicago sativa* and *Triflorum repens* (Bean 1960).

Leguminous shrubs like *Leucaena glauca* are studied in detail in Australia for introduction into the pasture environs with a variety of local soil types. There seems to be no attempt so far of similar studies on introduction ecology in India.

Dichanthium/Bothriochloa grassland type in Upper Gangetic plain supports legumes like *Desmodium triflorum, Alysicarpus longifolius, Indigofera linifolia, Crotalaria medicaginea, Desmodium gangeticum* and *Alysicarpus monolifer.* Generally forest grasslands seem to lack in leguminous plants as their associates except along river courses and human habitations where populations of *Cassia* and *Crotalaria* establish over disturbed habitats. Legumes reported in *Dichanthium/Cenchrus* grassland type are the following : *Tephrosia purpurea, Tephrosia villosa, Crotalaria burhia, Cassia occidentalis,* and *Cassia auriculata* ; *Indigofera hirsuta, Alysicarpus rugosus* and *Rhyncosia* sp. are recorded in *Sehima/Dichanthium* grassland. On usar lands, *Heylandia latebrosa* and *Indigofera* sp. are found growing mixed with grasses like *Eriochloa ramosa, Chloris virgata* and *Eragrostis ciliaris* ; *Cymbopogon* grassland supports legumes like *Crotalaria linifolia, Indigofera triata* and *Indigofera glandulosa* on lateritic soils (Whyte 1957). No legumes are recorded in the lists of plants collected from Alpine habitats in Himalayas except the rare presence of *Astragalus sikkimensis* (Smith 1913). This is in confirmity with the belief that Alpine grasslands are usually restricted in flora and contain no legumes (Davis 1954). Scientific data on pasture trails with grass and legume combinations is very meager. A mixture of *Cynodon dactylon* and *Medicago tribuloides* is found to develop into good sward during winter months in Bihar ; life of this pasture is possible to extend further by inclusion of *Medicago lupina* (Mandal 1955). *Cenchrus ciliaris, Phascolus mungo* and *Melilotus parviflora* is another combination for better sward development (Mandal and Chatterjee 1953). Most of the indigenous legumes cited in grassland types are left without trials for pasture improvement.

Grassland Soils :

Grasses grow on soils left fallow or forest habitats denuded of trees. Some grasses like *Saccharum spontaneum, Imperata cylindrica* and *Cymbopogon* sp. even readily colonize freshly deposited sands or even river-beds. This is because of low moisture requirement of grasses as compared to allied growth forms. It is earlier mentioned that *Dichanthium/Bothriochloa* grassland type is the natural plant cover on uplands of river Ganges at Varanasi. The colour of the surface soil is pale brown (10 YR 6/3 ; 6/2 moist). Grazed areas in this region have porosity of 36% for the top soil layer. Because of frequent removal of plant cover, the surface soils become more sandy with low percentage of clay. Water holding capacity increases with soil depth ; kankar nodules of irregular shape are found at lower depths of soil. Generally nitrogen content is low. Water soluble salts increase with soil depth. Calcium is found high in top soil layers. Magnesium content is uniform throughout the rooting depth of the grassland. Potassium is concentrated in upper soil layers. Soil reaction varies from 6·7 to 7·0 pH. Grassland soils of hills which are subjected to leaching and erosion, reveal poor nutrient status on comparison to alluvial grassland soils (Ramam 1960). In the opinion of the present investigators the removal of trees and shrubs might be a possible factor for high calcareousness noticed in grassland soils at Bettiah, Champaran district, Bihar (Verma 1961). Grasses also serve as site indicators. Grasses being shallow rooted are the best indicators of soil conditions as discussed by Misra (1957). *Saccharum narenga* is the dominant grass on soil most favourable for the growth of *Shorea robusta. Phragmites karka* and *Arundo donax* are indicators of grounds which are too wet for all but a few swamp species like *Bischoffia javanica, Putranjiva roxburghii* and *Imperata cylindrica* which tend to grow on cleared areas where the soil is heavy clay as shown by Troup (1926). Bor (1941) has grouped the grasses of Uttar Pradesh as indicators of very dry, dry, moderately dry, moist and wet habitats.

There seems to be no practice in India of maintaining pastures and swards in agricultural husbandry. Even the pastures noticeable round about the villages, are often over-grazed which results in cattle tracts and gully erosion. Rennovation of grasslands in India seem possible by rotational grazing and chemical manuring for better yields of herbage. There is every possibility of augmenting yields of grasses by dressings of nitrogen and phosphate fertilizers.

It has been stated (Dhar 1961) that five million tons of nitrogen are fixed by legumes in the world soils. Besides, not less than 150 million tons of nitrogen are partly supplied by the photochemical fixation of Nitrogen, the solar oxidation of organic matter on the surface of the soil and partly by the soil humus for the grassland production. Pasture lands of America receive 3% of nitrogen from fertilizers while the rest is by solar oxidation and photochemical fixation of atmospheric nitrogen (Dhar 1961). For pastures in India, urine and dung of the livestock are available sources of nitrogen but even this source is not utilised. Nitrogen deficiency is wide spread in Indian soils. Zende and Kundalkar (1954) supplemented organic manures with fertilizers for manuring natural grassland supporting species like *Themeda cymboria*, *Eulalia argentea*, and *Ischaemum aristatum* ; manuring of grassland increased the herbage yield by 1·02 tons per acre. Legumes are found to be absent in natural grassland as result of manuring. Nitrogen fertilizers seem to extend the grazing season for temperate climatic conditions ; it seems that nitrogen applications are only of interest when rotational grazing is practised (Voisin 1959).

Subterranean Organisation :

Stratification is the occurrence of organisms or their parts at more or less definite levels. It is usually applied to the aerial parts of the plants but is also characteristic of underground parts. Increasing attention is being given to root systems and their stratification since the studies of Weaver (1919, 1920). The earlier work on root systems including layering of various species, while in recent work layering is used more or less as a tool to explain the vegetational processes and as an aid to solve problems of range lands (Hanson and Stoddart 1940). Fresh weight of the aerial shoots of the vegetation in a $4m^2$ quadrat was determined and compared with total weight of the underground parts in Savanna associations of lower Congo by DeVred (1956). The results showed a remarkable regularity ; in the mesophytic association the overground/underground ratio approached unity. In semi-desert and desert vegetation, according to the same author, the ratio may be less than one.

The growth of root systems of plants into definite layers of soil is a structural function of plant organisation. This is influenced, within limits, by edaphic factors. For alluvial soils conditions, the available soil moisture influences root extension of grassland species to a large extent. Root layering as found in *Dichanthium* grassland (Ramam 1960*a*) led to classify forbs and grasses into three categories based on root behaviour. Thus the first category of meadow species with rooting depth in the range of 0–20 cm. are the following : *Setaria glauca*, *Alysicarpus longifolius*, *Blumea lacera*, *Croton sparsiflorus*, *Eclipta alba*, *Triumfetta neglecta* and *Striga euphrasiodes*. The second category of meadow species with maximum rooting depth range in the 0–40 cm. layer are : *Sporobolus diander*, *Blumea eriantha*, *Corchorus acutangularis*, *Evolvulus* spp., and *Veronica cinerea*. The third category of meadow species with rooting depths upto 60 cm. are : *Bothriochloa pertusa*, *Imperata cylindrica*, *Alysicarpus monolifer*, *Desmodium triflorum*, *Indigofera linifolia* and *Tephrosia purpurea*.

Root Productivity :

Setaria glauca : Annual grass of variable growth forms are found as tall and dwarf types scattered all over the short grass plains near Varanasi. It is dominant grass of meadows mixed with populations of *Cynodon dactylon*, on alluvial plains exposed to severe disturbance of cutting and scrapping during the monsoon. Roots are shallow, brownish and permeate the top soil layers. The quantity of root production on oven dry-weight basis per 25 cm.^{2} area of the sward was 0·61 to 2·55 gm. Soil binding capacity factor for *Setaria glauca* ranges from 1120 to 6375.

Sporbolus diander :

Annual trufted grass, 20 to 45 cm. tall, slender and glabrous leaves with very fine tips. The grass is frequent on play grounds, road sides and grazed pastures. It survives trampling. Tillers are produced copiously during the growth season of August, September and October months. Trampling might be a possible factor in slowing down shoot growth. Maximum root productivity for this seasonal grass per 25 cm.^{2} soil block is estimated to be 16·62 gm. of oven dry material. Soil binding capacity of *Sporobolus diander* is quite high with a range of 10,677 to 45,023; such a high range is possible because of fine fibrous root system.

Cynodon dactylon :

A perennial grass with prostrate clums, roots at the nodes and forms mat on the soil. The grass mostly occurs on abandoned cultivation, paths and depressions where water collects. It is a good sand binder. It makes a sort of turf at the edges of streams or in low flats.

This perennial grass develops spreading stolons immediately beneath the soil surface. Intricate and rigid net work of runners in the top soil with massive fibrous root system ranks the species as good soil binder with root productivity of 28 gm. per 25 cm.^{2} soil block. Maximum soil binding capacity factor for *Cynodon dactylon* was calculated as 11,102.

Imperata cylindrica ;

A perennial grass arises from a deep seated much branched rhizome. This is the most wide spread grass in tropics and survives the influence of fire and grazing and invades forest areas. Roots penetrate 58 cm. deep and can withstand soil drought of hot months. Soil binding capacity factor ranges from 10,710 to 29,454 for alluvial soil conditions.

Bothriochloa pertusa :

This is a perennial rhizomatous grass with slender culms sub-erect or geniculately or often weak, trailing and rambling on the ground.

Growth of roots and spread of rhizomes generally proceed for a period of 18 weeks followed by longer period of dormancy for the rest of the year in the dry soil. Seasonal growth of roots imposes a check on total root productivity which is found to vary from 26·72 gm. to 56·03 gm. of oven dry material. Soil binding capacity factors for *Bothriochloa pertusa* usually lie between 6372 and 14,135.

Dichanthium annulatum :

This is a deep rooted perennial grass dominant over other grasses of meadows on western uplands at Varanasi. The rhizomes are indeterminate in their spread but for a short period of dormancy during the moist soil phase during rains,

Because of biotic pressure on *Dichanthium grassland*, rhizomes of this grass are worst hit as shown by gradation of root productivity from 26·5 gm. to 206 gm. of oven dry material. Maximum soil binding capacity factor for *Dichanthium annulatum* is found to be 29,001 ranking next to *Imperata cylindrica* among the deep rooted meadow grasses (Ramam 1960*a*).

Grass roots improve soil structure by extensive ramifications of their fine branches into soil mass. Capacity of grasses to stabilise the soil mass depends on their root productivity which has direct bearing on vertical and lateral extensions of roots. It is shown earlier that *Sporobolus diander* is the best soil binder among seasonal grasses while *Imperata cylindrica* ranks first among perennial grasses with high soil binding capacity factor for alluvial soil conditions. Thus grasses serve as soil stabilising agents.

Grass and Animal :

A pasture plant or herbage plant must be capable of growing again after it has been cut either by the tooth of the animal or by the blade of the mower. Every new growth is dependent upon the reserve stocks of organic substances in roots or lower parts of shoot. Herbage plants may possess stock of other substances probably harmonal in nature which enable regrowth after every cut (Whyte 1950).

The general pattern of growth of living organisms is depicted by sigmoid shape of growth curve (Bonner and Galston 1952). Temperate grasses present serrated type of regrowth curve but in general sigmoid type of curve is typical of grass regrowth after defoliation (Andre Voisin 1959). Regrowth patterns in grasses depend upon region and prevailing climatic conditions in the seasons of year. In Upper Gangetic plain *Bothriochloa pertusa* completes vegetative growth in monsoon while *Dichanthium annulatum* initiates fresh growth on alluvial plains of Varanasi after rains. These grasses serve as experimental material for studies on regrowth patterns after defoliation.

Grazing animals seem to prefer species and varieties that grow normally and naturally under local conditions. In general cows prefer to graze plant communities in dry, as opposed to wet places. Perhaps it is also because of the dampness that cows on a pasture graze less readily in the shade than on sunny spots (Barbara Mott 1955).

It is prevalent practice that fodder is supplied as feed in the stall or alternatively, allowing the animal to feed on pastures or swards with grass under foot. In India stall feeding is preferred in cities while grazing on swards is common in rural areas where dry farming is practised.

Palatibility seems to be the link between the grass and animal and is influenced by variables such as animal itself, stage of growth and development of herbage and the management of pasture according to Voisin (1959). It is logical to understand the effects of grazing animals on the dynamics of pastures. There is paucity of data on this aspect in India. General trend of over-grazing is towards depletion of palatable grasses and increase of weeds and coarse grasses like *Desmostachya bipinnata* and *Imperata cylindrica*. In forest grasslands plants like *Butea monosperma*, *Holarrhena antidysenterica*, *Woodfordia floribunda* and *Lagerstroemia parviflora* are avoided by cattle (Troup 1926), and these serve as indicators of heavy grazing in the hills. Overgrazed grasslands of Bengal are occupied by *Careya herbacea* and in Madhya Pradesh *Xanthium stumarium* (Bor 1942). Populations of forbs like *Cassia occidentalis*, *Cassia auriculata*, *Cassia tora* and *Crotalaria medicaginea* are indicators of degraded village pastures of plains.

Conclusions :

Indian grasslands are seral communities. Their relative stability is influenced by intensity of use and local site conditions.

Data on herbage productivity of grassland types already located is further to be sought.

Intensive pasture trials with indigenous grasses and legumes lead to specify combinations to suit local environs.

Fertility status of grassland soils is to be assessed for replenishing mineral deficiencies through chemical manuring.

Carrying capacity of Indian grasslands in relation to grazing animal and prevailing seasons is to be defined for scientific management of grasslands.

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FURTHER STUDIES ON DECIDUOUS FORESTS OF MAHARASHTRA

By

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The commonest vegetation type in Maharashtra is the deciduous forest and an area of about 51,000 sq. kilometers (out of a total of 67,000 sq. km. of forest area) is under deciduous forests of one description or other. Deciduous forests usually occur on Deccan Trap where the basaltic rocks are highly weathered and covered by shallow or deep layers of soil, and where the average annual rainfall is between 75 and 300 cm. Dry deciduous forests occur in areas receiving less than 150 cm. annual rainfall and moist deciduous forests occur in areas receiving 150–300 cm. rainfall. Edaphic and biotic conditions often bring about conspicuous local differences in the composition of plant communities.

The moist deciduous forests include those forests where the general physiognomy of vegetation is like that of a deciduous forest but where some superior species, which otherwise grow in mixed or semievergreen forests, are found intermixed. Such vegetation usually grows in protected areas, closed by the forest department or along water currents and in moist valleys. The forests sometimes have more than one tree canopy. There is, however, a paucity of orchids, mosses ferns and climbers.

Several useful timber species occur in these forests such as *Tectona grandis* Linn. f., *Terminalia crenulata* Roth, *Adina cordifolia* Hook. f., *Mitragyna parvifolia* Korth., *Lagerstroemia lanceolata* Wall., *Dalbergia* sp., *Syzygium cumini* Skeels, *Lannea coromandelica* Merr., *Anogeissus latifolia* Wall. and *Salmalia malabarica* Schott. and Endl., etc.

The deciduous forests of Maharashtra have recently been described in detail by Puri and Jain (1959, 1960), Puri and Patil (1960), Jain (1959, 1961 *a*, *b*), Jain and Karmarkar (1960) and Khisty (1963). In order to confirm the observations on plant communities in the deciduous forests the studies were further extended and the following pages briefly describe the plant communities at Abhipuri Hill and Mazeri Hill in Bhor Forest Range of Poona district. These hills are situated at about 40 km. south of Poona, (plate, fig. 1).

The vegetation was studied in quadrats by laying transects on the hill slopes during December 1957. Actual number of trees, shrubs and climbers occurring in each quadrat (size 5 × 5 meters) was recorded.

Climate : Mean temperature at Poona ranges from about 17·8°C to 41·1°C, though the lowest and the highest records are 1·66°C (1935) and 43·3°C (1897) respectively. The average annual rainfall and number of rainy days for Bhor are given in Table I below. Plate, fig. 1 shows the rainfall patterns in Poona district.

*Rainfall data for Bhor in Poona district (based on 53 years average)

Month	Rainfall in mm.	Number of rainy days
January	1·27	0·1
February	1·27	0·1
March	3·55	0·3
April	14·50	0·9
May	22·86	1·8
June	140·71	9·7
July	319·78	19·2
August	188·46	15·8
September	125·98	8·3
October	74·93	4·8
November	32·02	1·8
December	4·06	0·3

Abhipuri Hill —It is a low hill with flat top which merges above into a plateau. The main rock is the Deccan Trap basalt with a shallow cover of coarse soil. The aspect studied is the western slope. The gradient is gradual. The figures in Table II represent percentages of quadrats in which particular species were recorded.

Mazeri Hill—A northern slope of this hill was studied. The soil is similar to Abhipuri Hill. The data are given in Table II.

The forests chiefly have *Terminalia—Syzygium* tree community. *Emblica officinalis* Gaertn. and *Memecylon* form the sub-dominants. The commonest trees in the tree canopy are *Terminalia crenulata* Roth (plate, fig. 2), *Syzygium cumini* Skeels, *Terminalia chebula* Retz. and *Emblica officinalis* Gaertn. The second storey is composed chiefly of *Allophyllus serratus* Radl., *Glochidion hohenackeri* Bedd., *Randia dumetorum* †Hook. f. and *Embelia tsjariam-cottam* DC.

The commonest shrubs in these forests are *Pavetta crassicaulis* Brem. (Syn. *Pavetta indica* auct. non Linn.), *Lasiosiphon eriocephalus* Decne, *Carissa congesta* Wight, *Woodfordia fruticosa* Kurz. and *Carvia callosa* Brem.

Careya arborea Roxb., *Embelia tsjariam-cottam* DC., *Erythrina variegata* var. *orientalis* Merr., *Memecylon* sp., *Jasminum malabaricum* Wight and *Smilax zeylanicum* Linn. are some of the significant species seen on the northern slope but not recorded from the western slope. Saplings of *Maesa indica* Wall., *Carvia callosa* Brem., *Holarrhena antidysenterica* Wall. and *Woodfordia fructicosa* Kurz were not observed on the northern slope whereas they are common on the western slope.

At Abhipuri Hill *Terminalia crenulata—Randia dumetorum* community is dominant. *Lasiosiphon eriocephalus—Woodfordia fruticosa* community is common in undergrowth. The vegetation resembles the type described by Puri and Jain (1959) from Paud in Poona district.

*Obtained through the courtesy of Director, Meterology Office, Poona.

†The plant going under the names *R. dumetorum* and *R. brandisii* is now known as *Xeromphis spinosa* (Thunb.) Keay.

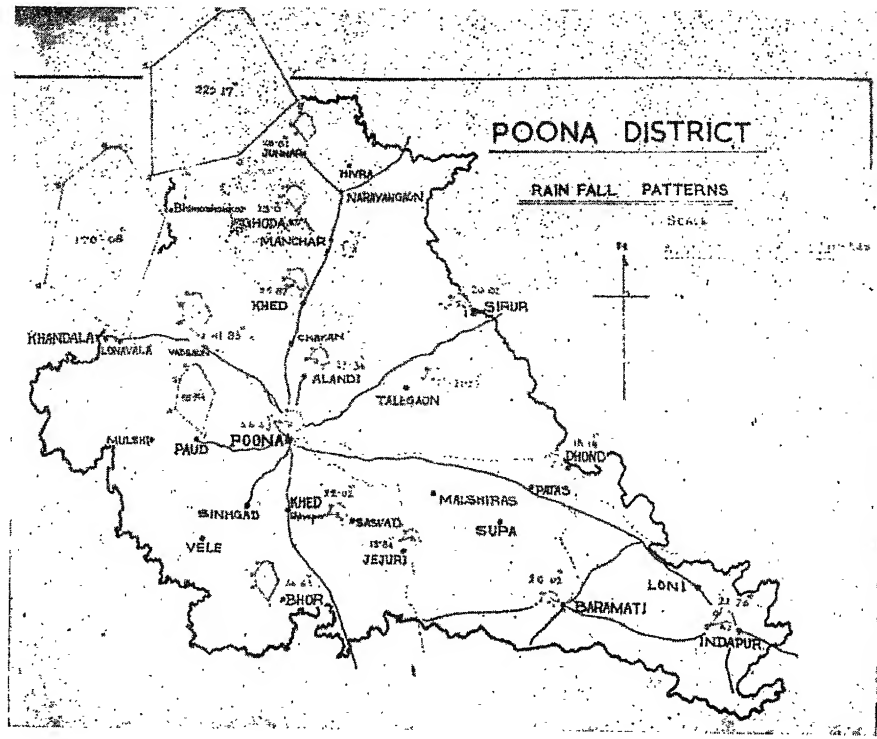

Fig. 1. Map of Poona district.

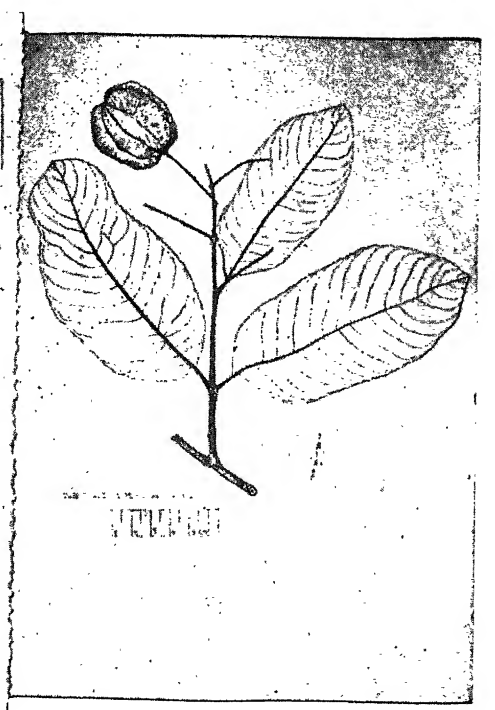

Fig. 2. *Terminelia crenulata* Roth.

TABLE II

Showing percentages of quadrats in which various forest species were recorded

Plant name	Abhipuri Hill	Mazeri Hill
Allophyllus serratus Radl.	40	60
Careya arborea Roxb.	—	12
Embelia tsjariam-cottam DC.	—	36
Emblica officinalis Gaertn.	40	48
Erythrina variegata var. *orientalis* Merr.	—	12
Ficus glomerata Roxb.	10	—
Glochidion hohenackeri Bedd.	50	60
Memecylon sp.	—	48
Randia dumetorum Hook. f.	60	48
Salmalia malabarica Schott. & Endl.	—	12
Syzygium cumini Skeels	40	36
Terminalia chebula Retz.	—	36
Terminalia crenulata Roth.	60	60
Zizyphus sp.	20	—
Undergrowth :		
Carissa congesta Wight	20	48
Carvia callosa Brem.	30	—
Cyclea burmani Hook. f. & Th.	10	36
Dioscorea bulbifera Linn.	30	12
Hemidesmus indicus (L.) Schutt	40	36
Holarrhena antidysenterica Wall.	20	—
Jasminum malabaricum Wight	—	48
Lasiosiphon eriocephalus Decne	70	24
Maesa indica Wall. (saplings)	80	—
Pavetta crassicaulis Brem.	20	84
Smilax zeylanica Linn.	—	72
Woodfordia fruticosa Kurz	60	—

At Mazeri Hill *Terminalia crenulata—Glochidion hohenackeri* tree community is dominant. Presence of *Terminalia chebula* Retz., *Emblica officinalis* Gaertn. and *Memecylon* sp. suggests 'moist' nature of the forest. *Allophyllus serratus* Radl. is very common in the second storey. The undergrowth is formed by *Pavetta* and *Carissa congesta* community. These species are usually found in moist deciduous forests or even mixed deciduous forests in Maharashtra. This confirms the earlier observations of Puri and Jain (1959). *Woodfordia fruticosa* Kurz which is an indicator

of degraded habitat conditions was not recorded in any quadrat and its absence also suggests better status of forest at Mazeri than at Abhipuri Hill. The presence of *Jasminum malabaricum* Wight and *Smilax zeylanicum* Linn. as common climbers at Mazeri Hill also supports this inference.

As observed in other localities of Maharashtra (*cf.* Jain, loc. cit.) here too *Syzygium cumini* Skeels occurs on lower parts of hill slopes. *Glochidion hohenackeri* Bedd. and sapling of *Maesa indica* Wall. were observed to be more frequent at lower slopes. *Carvia callosa* Brem. is more common on upper or middle parts of hill slopes. *Pavetta crassicaulis* Brem. and *Lasiosiphon eriocephalus* Decne are found almost uniformly distributed on the slopes.

The vegetation approaches the type described by Champion (1936) under Southern Indian Moist Deciduous Forest Type.

Summary :

The plant communities of the deciduous forests at Abhipuri and Mazeri Hills in Bhor Forest Range of Poona district have been described. *Terminalia crenulata* Roth is common timber species in these forests. A Table showing frequency of occurrence of different forest species is given.

Acknowledgements :

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ON A NEW FAMILY LILIATREMATIDAE OF THE SUPERFAMILY ECHINOSTOMATOIDEA FAUST, 1929 WITH A DISCUSSION ON ITS TAXONOMIC POSITION AND A KEY TO THE FAMILIES OF THE SUPERFAMILY ECHINOSTOMATOIDEA

By

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Allahabad

[Received on 6th March, 1962]

The subfamily Liliatrematinae Gubanov, 1954 is excluded from the family Cathaemasiidae Fuhrmann, 1928 in which Yamaguti (1958) placed it. It is elevated to the rank of a new family Liliatrematidae. Gubanov (1954) placed his genus *Liliatrema* and his subfamily Liliatrematinae in the family Allocreadiidae Stossich, 190 . But Yamaguti (1958) excluded it from the latter family as all its members are parasitic in fishes. *Liliatrema* Gubanov is parasitic in marine piscivorous birds. Its characteristic apical pentagonal hood-like expansion above the funnel-shaped oral sucker may be considered to represent the modified collar around the mouth. The pentagonal hood has one or two papillae at the tip of each of the five projecting lobes. It is a specialization of the anterior end of the body, more or less similar to the annular ridge around the oral sucker with three muscular lobes, one dorsal and two subventral of *Rhytidodes* Looss, 1901 or a pair of small projections, one on each side of the oral sucker of *Rhytidodoides* Price, 1939 belonging to the family Rhytidodidae Odhner, 1926 parasitic in turtles. A somewhat similar specialization in the form of a pair of retractile armed proboscis present one on each side of forebody characterises the genus *Rhopalias* Stiles and Hassal, 1898 of the family Rhopaliasidae Yamaguti, 1958 parasitic in Marsupials. The superfamilly Echinostomatoidea Faust is thus characterised by the presence of head collar or such specializations at its anterior end or in the forebody as mentioned above.

The prepharynx is absent in the new family as in the Rhytidodidae. The acetabulum is comparatively small and pre-equatorial. The testes are entire or lobed in the posterior half of body. The ovary is lobate. The cirrus sac does not extend behind acetabulum as in many members of Echinostomatidae and Psilostomidae. The genital pore is immediately pre-acetabular. In Rhytidodidae the excretory vesicle is Y-shaped with long arms. In Liliatrematidae n. fam. it is V-shaped. In some members of Psilostomidae it is also V-shaped as for instance, in *Psilorchis* Thapar and Lal, 1935. The family Liliatrematidae connects the families Echinostomatidae, Ommatobrephidae, Psilostomidae, Cathaemasiidae and Rhytidodidae. It belongs to the superfamily Echinostomatoidea Faust, rather than to Allocreadioidea Nicoll, as it stands in direct line of ancestory with the former superfamily. On account of the pentagonal hood-like expansion at the apex of the funnel-shaped oral sucker it comes under Echinostomatoidea, but in possessing a large receptaculum seminis and bipartite vesicula seminalis it stands close to Allocreadioidea. In its habitat in the gut of the piscivorous birds it stands close to the family Cathaemasiidae.

Allocreadiidae Stossich, 1903, Lepocreadiidae Nicoll, 1934, Deropristidae Skrjabin, 1958, and a few other families of Allocreadioidea Nicoll, possess a

tubular or saccular excretory bladder, whereas Liliatrematidae n. fam. has V-shaped excretory bladder which comes near the Y-shaped excretory bladder of Echinostomatoidea. Acanthocolpidae Luhe, 1909, a primitive family of Allocreadioidea, which has been evolved from the ancestor of the latter superfamily possesses a Y-shaped excretory bladder.

In Ommatobrephidae Poche, 1925 the excretory system is primitive, stenostomate with Y-shaped excretory vesicle of short stem and long fairly broad cornua extending forwards to the pharynx where they bend forming a loop to continue backwards as common collecting ducts. The vesicle represents the main short stem and the long more or less coiled limbs or cornua, the arms of the somewhat V-shaped excretory bladder. The exeretory system resembles closely that of some Echinostome cercariae and may, therefore, be considered as cercarial in pattern. It probably comes closer to that of Liliatrematidae n. fam. The excretory bladder of closely related family Philophthalmidae Travassos, which as known at present (Yamaguti, 1958) is a heterogenous group, has been evolved along a separate line from that of Cathaemasiidae, Echinostomatidae and Psilostomidae. Thus the excretory bladder though primitively V-shaped or Y-shaped with short stem possibly does not indicate any evolutionary plan in the superfamily, though it has become tubular in most highly evolved families Fasciolidae and Campulidae.

Acanthocolpidae lacks a receptaculum seminis like many echinostomids. It however, possesses a bipartite vesicula seminalis. Receptaculum seminis though absent in most families of Echinostomatoidea is large in Ommatobrephidae and Liliatrematidae. The vesicula seminalis is bipartite in Ommatobrephidae, Liliatrematidae and some genera of Echinostomatidae (subfamily Echinochasminae). It, therefore, becomes clear that Liliatrematidae n. fam. stands intermediate between Echinostomatoidea and Acanthocolpidae, the primitive family of Allocreadioidea. It has been evolved from the Echinostome ancestor of Allocreadioidea, which was parasitic in marine fish hosts and established itself in marine piscivorous birds.

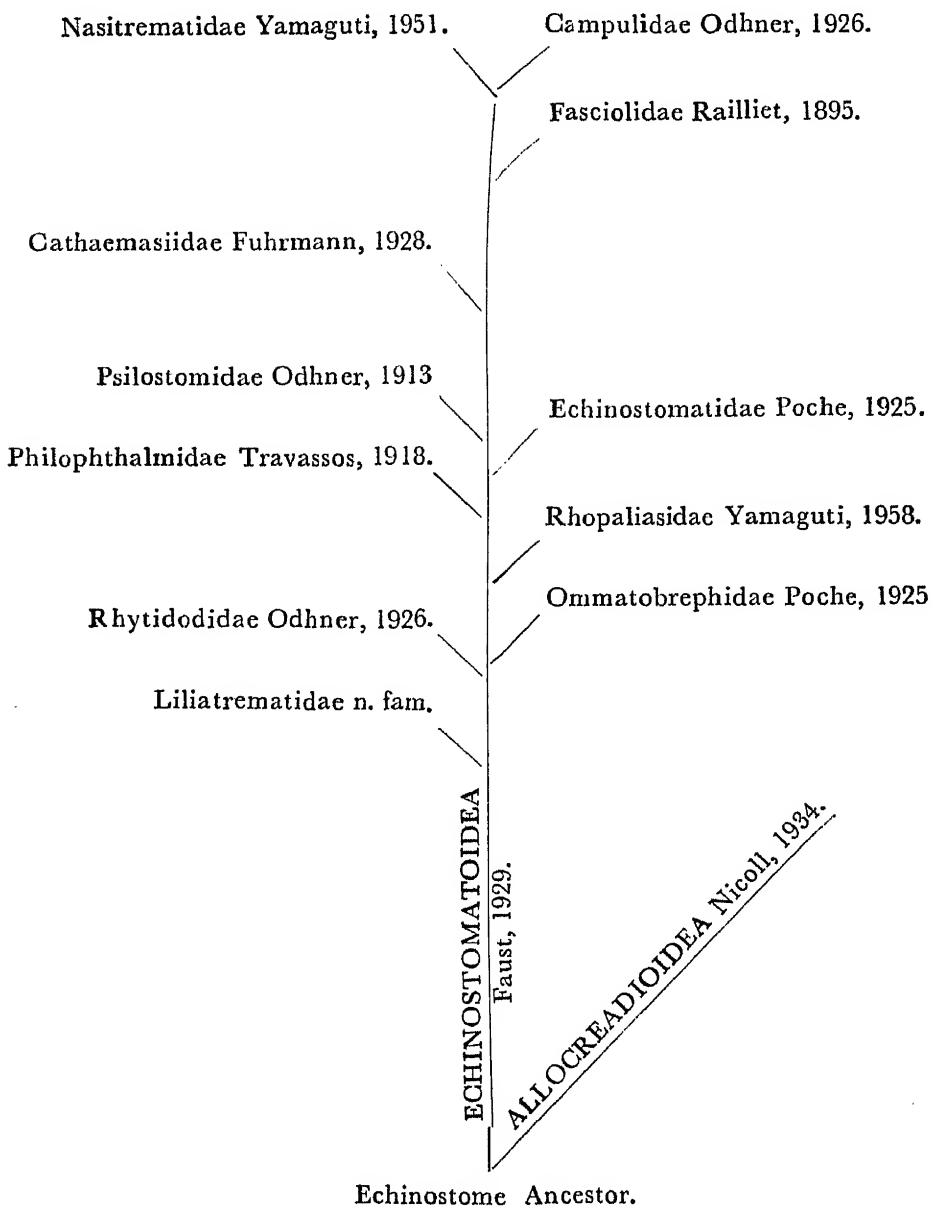
The funnel-shaped oral sucker with apical pentagonal hood-like expansion in Liliatrematidae n. fam. and the modified annular ridge with three muscular lobes of *Rhytidodes* Looss or a pair of small projections one on each side of the oral sucker of *Rhytidodoides* Price are examples of extraordinary modifications of anterior end of remarkable evolutionary mutational changes due possibly to isolation in parasitic environment through the long geological evolutionary history of their hosts from fishes, reptiles to birds in the case of Liliatrematidae and from fishes to turtles in that of Rhytidodidae.

Liliatrematidae n. fam.

Family diagnosis.—Echinostomatoidea : body small to medium sized, subcylindrical, flattened, spinulate. Oral sucker funnel-shaped, with a pentagonal hood-like expansion at apex bearing one or two papillae at tip of each lobe. Acetabulum comparatively small, pre-equatorial. Prepharynx absent. Pharynx longer than broad. Oesophagus short ; caeca terminating near hinder end. Genital pore immediately pre-acetabular. Testes tandem, entire or lobed, in posterior half of body. Vesicula seminalis bipartite contained within cirrus sac. Cirrus sac not extending behind acetabulum. Ovary divided into two or three lobes, submedian, about half way between acetabulum and anterior testis. Receptaculum seminis large ; post-ovarian. Vitellaria lateral in hind body, extending from level of pharynx or level of ovary to posterior extremity. Uterus coiled, intruding in preacetabular area. Excretory vesicle V-shaped. Parasitic in gut of marine piscivorous birds.

Type genus : *Liliatrema* Gubanov, 1954.

The family Cathaemasiidae Fuhrmann, 1928 parasitic in fresh-water birds includes two subfamilies Cathaemasiinae Dollfus, 1950 and Riberoliinae Travassos, 1951 after the elevation of Liliatrematinae to the new family Liliatrematidae.



Diagrammatic phylogenetic tree of Echinostomatoidea.

Key to families of Echinostomatoidea Faust.

1. Head collar present.....Echinostomatidae Poche, 1925.
   Head collar absent.....2.
2. Armed proboscis present symmetrically one on each side of forebody; parasitic in Marsupials.....Rhopaliasidae Yamaguti, 1958, for Rhopalidae Looss, 1899.
   Armed probocis absent.....3.
3. Oral sucker funnel-like with apical pentagonal hood-like expansion at apex; excretory vesicle V–shaped ; parasitic in marine piscivorous birds .....Liliatrematidae n. fam.
   Oral sucker without pentagonal hood-like expansion ; excretory vesicle typically Y-shaped or tubular ; parasitic in reptiles birds and mammals.....4.
4. Excretory vesicle Y-shaped.....5.
   Excretory vesicle tubular.....7.
5. Oral sucker with annular ridge consisting of three muscular lobes or oral sucker with one small projection on each side ; parasitic in turtles.....Rhytidodidae Odhner, 1926.
   Oral sucker ordinary without above mentioned characters ; parasitic in lizards and snakes or birds and mammals.....6.
6. Cornua of excretory bladder long, simple of Echinostome cercarial pattern, without outgrowths ; parasitic in lizards and snakes..... Ommatobrephidae Poche, 1925.
   Cornua of excretory bladder long, with numerous outgrowths ; parasitic in birds .....Philophthalmidae Travassos, 1918.
   Excretory bladder sometimes V-shaped, cornua without lateral branches; subcutaneous excretory network usually present ; parasitic in birds and mammals .....Psilostomidae Odhner, 1913.
   Cornua of exeretory bladder without lateral outgrowths and subcutaneous network ; parasitic in freshwater piscivorous birds Ciconiformes.....Cathaemasiidae Fuhrmann, 1928.
7. Parasitic in terrestrial mammals except Marsupials.....Fasciolidae Railliet, 1895.
   Parasitic in marine mammals.....8.
8. A pair of collateral excretory vesicles opening into main excretory vesicle present ; cirrus sac absent ; testes strongly branched.....Nasitrematidae Yamaguti, 1951.
   A pair of collateral excretory vesicles absent ; cirrus sac present ; testes not branched.....Campulidae Odhner, 1926.

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THE MORPHOLOGY OF A NEW TREMATODE *MEHRAFORMIS JABALPURENSIS*, n. g., n. sp. (MICROPHALLIDAE TREMATODA)

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[Received on 20th April, 1961]

Introduction :

While surveying reptilian fauna of Jabalpur region for trematodes, two very interesting worms were discovered from the duodenum of *Varanus* sp. The new worm is being described here under the name of *Mehraformis jabalpurensis* n.g., n.sp. More than 35 specimens of the new form were found, and then were found to be belonging to the family *Microphallidae* Travassos, 1920, and due to the presence of a cirrus sac it has been placed in the subfamily *Maritrematinae* Lal, 1939. The worm of this family mainly occur in birds and mammals, and only one information exists of the occurrence of *Microphallus opacus* (Ward, 1894) Ward, 1901, sgn. *M. ovatus* Osborn, 1919, in a reptilian host. Moreover, the subfamily *Pseudosellactoylinae* Yamaguti, 1958 has been reported only from fish hosts, some members of the subfamily *Microphallinae* also occur in fishes. No microphallids have ever been reported from amphibians ; neither any microphallid except *Marophallus opacus* had ever been reported from reptilians. Hence the importance of the present report. The fact that more than 35 healthy adults could be obtained from a single host shows that in this region at least it is a well established parasite in these reptiles ; and obviously, the new find will contribute to bionomical studies of the family Microphallidae.

The following is a list of the genera so far attributed to the subfamily *Maritrematinae* Lal, 1939 :—

1. *Maritrema* Nicoll, 1907, syn. *Streptovitella* Swales, 1933.
2. *Gynaecotyla* Yamaguti, 1939, syn. *Cornucopula* Rankin, 1939.
3. *Diacetabulum*, Belopolskaia, 1952.
4. *Maritreminoides* Rankin, 1939.
5. *Microphalloides* Yoshida, 1938.
6. *Numeniotrema* Belopolskaia, 1952.
7. *Odhneria* Travassos, 1921.
8. *Pseudospelotrema* Yamaguti, 1939.
9. *Pseudomaritrema*, Belopolskaia, 1952.
10. *Pseudospelotrematoides*, Yamaguti, 1939.

All the above mentioned genera occur in birds excepting, the genera *Maritrema* and *Microphalloides* which are occurring in mammals so well. And on account of its special morphological features and an altogether new type of host, the creation of the present genus, viz, *Mehraformis jabalpurensis* n.g. n.sp. is felt necessary.

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Material and Method :

The worms were obtained from a freshly killed animal from its foregut region. They were studied alive, and later on fixation of the worm in Bouin's aqueous fluid, under a slight pressure of coverslip, in order to preserve the correct form of the animal, was done. Subsequently they were studied from permanent preparations. The stains used are Acid alum carmine, Borax carmine, Carmalun, Haemalum, and Ehrlich's haematoxylin.

All measurements are in millimetres.

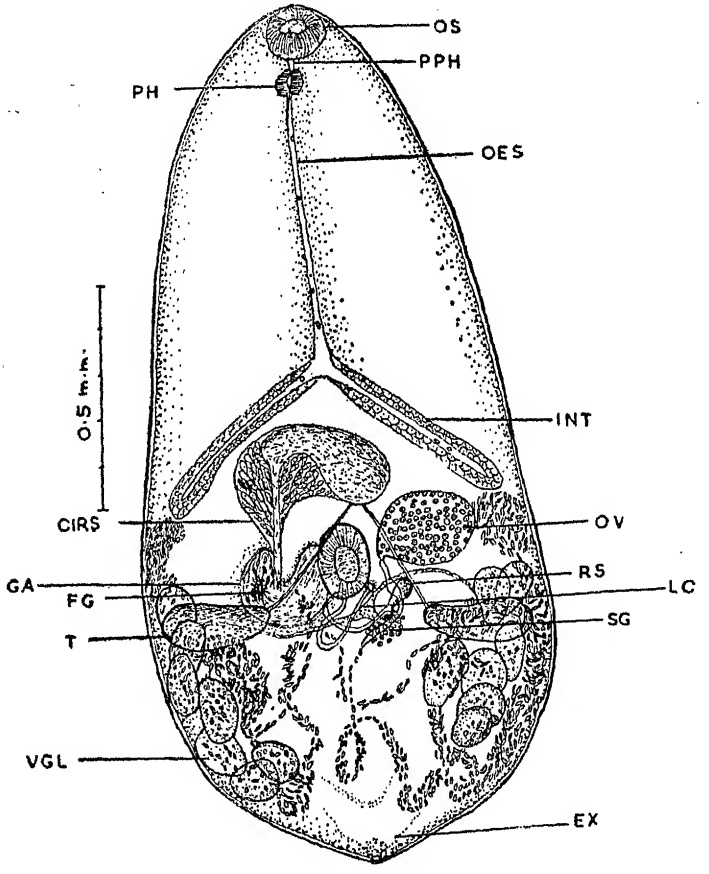

Fig. 1 was made with the help of camera lucida : Ventral view showing the morphological features of *Mehraformis jabalpurensis* n.g. n.sp.

ABBREVIATIONS

ACET, acetabulum ; CIR, cirrus ; CS, cirrus sac ; CVR, median vitelline reservoir ; CVD, median vitelline duct ; DL, Laurer's canal ; DRS, duct of the receptaculum seminis ; EX, excretory vesicle; EXP, excretory pore ; FG, female genital pore ; INT intestinal caeca ; OS, oral sucker ; OES oesophagus ; OV, ovary ; OT, ootype ; OL, dorsal opening of the laurer's canal ; OVD oviduct ; PPH, prepharynx ; PH, pharynx ; RS, receptaculum seminis ; T, testis ; UT, uterine coils ; VGL, vitelline glands.

Description :

Mehraformis jabalpurensis n.g., s.np. (fig 1). The worms are small, varying in shape from ovate to elongately pyriform. The body is slightly concave ventrally, and the posterior half is more muscular, and hence as appearance of 2 colours to the naked eye when the parasite is alive, *viz*, pinkish posteriorly, white anteriorly. The body is spinulate, the minute spines extend only upto the line of acetabulum, and the spines are spasser posterioral. The body measures from 1·162×0·78 to 1·876×0·880. The acetabulum is situated more or less in the middle of the posterior body (the body after the intestinal bifurcation). A prominent genital atrium more or less overlaps the acetabulum. The oral sucker is more or less rounded, ventroterminal, and rather feeble. A small or sometimes indistinct prepharynx follows the oral sucker, measuring 0·025 or less in length. Pharynx is also very feeble, measuring 0·. 42 in diameter or less, the oesophagus is quite long and slender, 0·6 in length or a little more or less. The oesophagus bifurcates in a field a little before the equatorial plane, at this place or a little beyond this plane. The intestinal crura are short, straight, stout, and diverging, they end just in front of the acetabulum--in some forms the intestinal crura have become even smaller.

The testes are elongately oval, and lie horizontally, symmetrically on each side almost touching the body margin, in a plane posterior to acetabulum. Generally they are partially or wholly covered by vitelline follicles and interine coils. From each testes a straight vas eferens emerges to join the large vesiculum seminis which is medially situated, postbifurcal and preacetabular. A cirrus sac encloses the seminal vesicle and other ducts. From the seminal vesicle emerges a prostatic duct, the prostatic glands are quite big, flask-shaped, and fill the entire cirrus pouch of that region. The ductus ejaculatories is a stout eversible duct, which passes into a small muscular papilla through which it opens on the dorsal floor of the genital atrium. The genital atrium is quite big and apposing the acetabulum, it may give it a lateral flattening, and sometime it overlaps the acetabulum. The seminal vesicle measures 0·282×0·1494, the prostatic duct is 0·1162×0·025, the genital atrium is 0·2324 > 0·2324. The genital atrium is dextral. The ovary is big and ovately spherical in shape, lying on the left upper margin of acetabulum, measuring 0·2158×0 1494. The female apparatus is quite distinctly seen and interesting. The oviduct near the beginning of the ootype is joined by a small, anteriorly orientated, pearshaped or pyriform receptaculum seminalis through a short duct. The laurer's canal joins the receptaculum seminis before it enters the oviduct. The laurer's canal makes a single loop at posterior margin of the acetabulum and then a bigger one downwards, and after crossing the vitelline reservoir opens dorsally near the left margin of the acetabulum, and obliquely below the ovary. The ootype is surrounded by some mehlis' gland cells, and continues in the uterus in the median plane. The uterus forms coils on the left side and then it passes through the middle of the body in a single line and forms more coils on the right side. The median field is much clearer, anteriorly the coils of the two sides reach upto the cecal endings. The vitelline follicles in these parasites are extremely large and ovate in shape, situated symmetrically on the margin, lying one above the other and overlapping each other. Their number in never below 7 and does not exceed 9 in any case. The two main vitelline ducts emerge from the anterior margin of the vitellaria, and anterior to the ootype, and obliquely, a common vitelline reservoir is formed which is opening into the ootype almost in the middle from the anterior side ; after the latter has received the duct of the receptaculum seminalis. The uterus does not form any prominent metraterm, and the female genital opening is separately found in the genital atrium, always to the right of the male genital opening, and it appears to be

regulated by a short of sphincter arrangement. The eggs are elliptical, relatively large, numerous (but not too many), light yellow when unstained and alive, operculate. They are small in size, measuring 0·0264×0·0132 to 0·0297×0·0148.

The excretory bladder is V-shaped. The arms of Vare stout do not go beyond the posterior margin of the acetabulum.

The excertory pore is ventroterminal

Hose	...	*Varanus*
Location	. .	Foregut
Locality	...	Jabalpur, India

Mehraformis n.g.

Generic diagnosis—Microphallidae, Maritrematinae : Body small, elongately pyriform, broader posteriorly, spinose, posterior half thicker than the anterior half, bicoloured when alive. Oral sucker ventroterminal, prepharynx distinct but quite small, oesophagus long, ceca stout and short, divergent, ending in preacetabular field. Acetabulum not very strong, larger than oral sucker, situated just at the beginning of the posterior third of the body. Testes placed symmetrically near body margins, just postacetabular, big prostatic glands, all enclosed in cirrus sac, cirrus sac in front of acetabulum and postbifurcally placed, in median plane. Cirrus runs in the form of simple and stout duct enclosed terminally by a muscular papilla, opening in a spacious genital atrium which overlaps the acetabulum. Genital pores dextral to acetabulum. Ovary more or less rounded, on left of acetabulum between left testes and seminal vesicles. Uterus mainly spreading on lateral fields touching cecal endings, median field being relatively clear. Receptaculum seminis and well developed laurer's canal present. Vitelline follicles large, situated marginally overlapping, one behind the other or so, numbering 7–9 in either side, overlapping testes, and ending in plane below overy. Excretory vesicle V-shaped, with stout moderately long arms. Intestinal parasites of reptiles.

Type species—*Mehraformis jabalpurensis*

Key adapted from Yamaguti (1958) to place the new genus.

Subfamily *Maritrematinae*

1. Male and famele pores sparate.....1 *a*, 1 *b*

   1*a*. Male and female genital pores separate female pores sucker-like ; laurer's canal absent or present ; uterus occupying the hind body completely.....*Gynaecotyla*

   1*b*. Male and female genital pores separate, famale pore simple, a well developed laurer's canal present, uterus occupying mainly the mareginal fields..... *Mahraformis*

   Male and female pores not separate.... 2

2. Acetabulum double, ceca turning inwards in front of testes.. *Diacetabulum*
   Acetabulum single, caece not turning inwards..... 3

3. Genital atrium simple..... 4

   Genital atrium complex..... 5

4. Vitellaria marginal, at ovariotesticular level, seminal vesicle elongately saccular, ovary lateral to acetabulum, uterus tending to extend into forebody on each side..... *Pseudospelometra*

Vitellaria immediately pretesticular, seminal vesicle tubular, convoluted, ovary lateral to acetabulum, uterus confined to posttesticular hind body..... *Pseudospolometroides*

Vitellaria largely anterior and lateral to testes, seminal vesicle tubular, not convoluted ; ovary lateral or posterolateral to acetabulum.....*a.*, *b.*

(*a*) Uterus forming a loop on each side of forebody..... *Maritrematoides*

(*b*) Uterus confined to inter and posttesticular area..... *Odhneria*

Vitellaria extending obliquely from pretesticular lateral area to posttesticular median area, seminal vesicle elongate saccular ; ovary median..... *Pseudomaritrema*

Vitellaria extending posttesticular lateral margin of body, seminal vesicle bipartite ovary median..... *Numeniotrema*

5. Vitellaria encircling testiculo uterine region in achainlike formation ..... *Maritrima*

Vitellaria immediately interior to ceca..... *Microphalloides*

Discussion :

Firstly, the new genus is peculiar due to its absolutely new reptilian host *Varanus* sp. and due to the presence of the cirrus sac it has been put under the subfamily *Maritrematinae* Lal, 1939. Under this subfamily, due to the presence of a separate male and female genital pores and certain other anatomical features, *viz*, topography of the internal organs, it naturally comes closer to the genus *Gynaecotyla* Yamaguti, 1939, syn. *Carnucopula* Rankin, 1939. The new genus resembles very much the genus *Gynaecotyla* in the sinistral position of its ovary, the situation to right of the acetabulum, of the genital atrium, the separation of the female genital pore, and the situation of the testes in the postacetabular field. At the same time this new genus differs from this genus in certain important features of its anatomy, *i.e.*, the female genital opening is not sucker-like as it is in Gynaecotyla, the nature and number of vitellaria is peculiar in the new genus, its uterus spreads in marginal field and the loops of the uterus reach the cecal endings, with only a few coils in the median fields, unlike *Gyaecotyla* in which the uterus fills the hind body. Other differences are, in the new genus, the prepharynx is shorter, presence of body spines in the forebody region. Moreover, it has resemblance to one or the other individual features of the different genera of the family *Microphallidae*. And it may he concluded that the combination and the nature of the characters found in this genus, and its novel host leave one in no doubt that this is the case of a new genus and a new species.

The redefinition of the family Microphallidae Travassos, 1921 by Cable and Kuns (1951) has taken into consideration the importance of cirrus pouch, for the purpose of generic separation. And on the same basis the present genus has been placed under the subfamily Maritrematinae Lal, 1939. Further, it is significant to note that the present form has a well developed receptaculum seminis and a stout laurer's canal which has distinctly opened below the ovary, by the left side of the acetabulum. Cable and Kuns (1951) indicated that the presence of a seminal receptacle in the family *Microphallidae* was yet to be confirmed, and a fertilization chamber may have been misinterpreted as a seminal receptacle.

In the light of the discussion by Donald W. Dery (1958) and his report of the new species *Gynaecotyla riggini* Dery, 1958 the position of the genus *Gynaecotyla* Yamaguti, 1939, Charc. emend. Dery, 1958 is quite clear. *Gynaecotyla riggini* definitely

links the genus *Gynaecotyla* to the other members of the family *Microphallidae*, and it is therefore also linked with the new genus *Mehraformis*. And now, we may place *Mehraformis* n.g. in a position interemediate between *Microphalloides* Yoshida, 1917 and *Gynaecotyla*. The presence of a female genital opening without a sucker is probably a more primitive character than the femalegenital opening with a sucker, as is the case in the genus *Gynaecotyla*. In the opinion of the author the character of the structure of a genital opening is of a considerable evolutionary significance.

Summary :

This very interesting new worm was discovered from the duodenum of *Varanus* sp. The new genus *Mehraformis* has been duly placed in the subfamily *Maritramatinae*. In brief the record of the microphallids from the animal kingdom is discussed. And it is interesting to note that hitherto, leaving only one accidental occurrance of *Microphallus opacus* (Ward, 1894) Ward, 1901, syn. *M. ovatus* Osborn, 1919 (subfam. Microphallinae), *not a single Microphallid has ever been reported from the reptiles* ; hance the uniqueness of the present report. The relationships of the new trematode have been discussed, and the genus *Gynaecotyla* is considered its nearest relative. The presence of the receptaculum seminis and laurer's canal has been established in the present form. A key to the genera of the subfamily Maritrematinae has also been adduced. The new genus is considered to be of great bionomic significance.

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*Late Principal.

DDT RESIDUES ON TREATED PEA VINE SILAGE AND THE COWS' MILK WITH SPECIAL REFERENCE TO THE METHODS FOR ITS ANALYSIS

By

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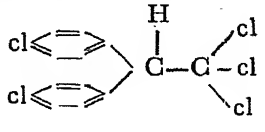
Investigations on the pharmacology of DDT indicated that DDT accumulated in the various tissues. Woodard, Ofner and Montgomery (1945) for the first time reported the presence of DDT in milk and fat tissues of dogs. Telford (1945) and Telford and Guthrie (1945) also found that secreted milk from goats and rats fed with high dosages of DDT, caused mortality to animals, to which it was fed. These reports rather caused alarm among the workers, who are using DDT against pest. In this direction Laug (1950), Sternburg *et al* (1960), Tahori *et al* (1953), Pradhan *et al* (1959) and Beri *et al* (1960) have also conducted researches.

Realizing the future hazard as to the effects which may be produced on infants and children by taking milk from cows fed on DDT treated silage, a systematic survey of the DDT residue studies have been carried on pea vines from the time of treatment until the harvest time and also on stacked silage and canned peas during 1946–1947.

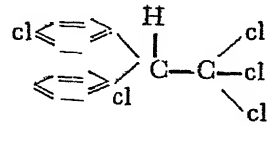
The main data was obtained from samples of vines and peas taken in experimental plots at Beaver Dam and Waunakee, Wisconsin, treated with dusts containing from 1 to 5% DDT. Simultaneously milk samples from cows fed with DDT silage were also analysed. Aphid was a serious pest of pea vines, the population of the aphids during 1947 is given in Graph No. 1.

DDT, the abreviation of the chemical compound "Dichlorodiphenyltrichloroethane", was first synthesized in 1874 by Othmar Zeidler. The credit for discovering the insecticidal property of this material goes to Paul Muller, Chemist of Geigy Company of Basle, Switzerland. He synthesized this product and discoverd that a very small amount of DDT in combination with a dispersant gave a remarkably effective and durable insecticide.

Two main isomers of technical DDT



1-trichloro-2, 2-bis-(p-chlorophenyl)-ethane
(p,p'-DDT)



1-trichloro-2-(o-chlorophenyl-
2-p-chlorophenylethane
(o,p'-DDT)

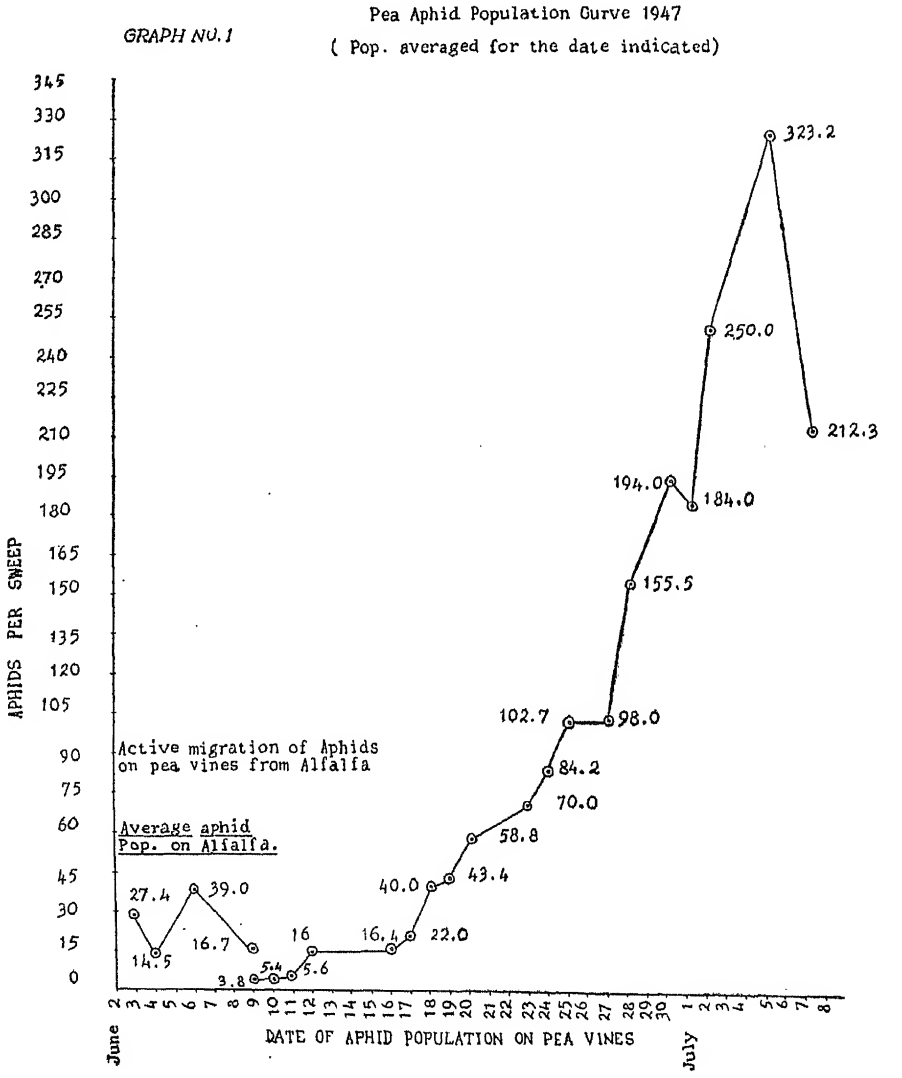
1. The investigations were conducted in the Department of Economic Entomology at the University of Wisconsin Madison U. S. A. as a State Scholar to the Government of India. Grateful acknowledgement is made to late Professor H. F. Wilson.

Technical DDT was prepared commercially from chlorinated alcohol and chlorobenzene and had been found to contain upwards of 70% of p,p'—DDT and less than 30% of impurity. The major impurity was o,p'—DDT (8 to 19%) and minor impurity consisted of twelve other organic compounds formed on the basis of side reactions involving chloral, chlorobenzene, sulphuric acid and impurities in the starting materials.

Methods for the determination of DDT.—(Gunther *et al* 1955).

A tabular classification of the various methods for the determination of DDT is briefly given below :

1. Biological assay.—Laug (1946)



2. Chemical methods.—A—colorimetic methods

(*a*) Pyridine-xanthydrol reaction —Stiff and Castillo (1945)

(*b*) Friedel Craft reaction—Bailes and Pyane (1945)

(*c*) Nitrated DDT in-Na-methylate reaction—Schechter and Haller (1944) and Schechter *et al* (1945)

(*d*) Zinc chloride-diphenylamine reaction—Jones (1945)

(*e*) p-p' DDT conc. H_2SO_4- glacial acetic acid reaction—Chaikin (1946).

(*f*) Hydroquinone-conc. Sulfuric acid reaction —Bradbury *et al* (1947).

B—Volumetric methods

(*a*) Total chlorine

(*i*) Combustion by modified Wintermethod—Hall *et al* (1944), Fahey (1945), Fleck (1945)

(*ii*) Reduction by metallic sodium in benzene—Food and Drug administion (1945).

(*iii*) Reduction by metallic sodium in alcohol—Smith and Stohlman (1944).

(*b*) Labile chlorine—(Dehydrohalogenation).—Neal and Coworkers (1944) and Gunther 1945.

(*c*) Gravimetric

(*a*) Crystallization—Cristol *et al* (1945)

3. Chemical methods for milk and fatty materials.

(*a*) Organic chlorine method—Carter (1947)

(*b*) Colorimetric method—Schechter, Haller and Pogorelskin (1949) and Schechter, Pogorelskin and Haller (1947).

DDT residues studies have been carried out on pea vines from the time of treatment until harvest time and also on stacked silage and canned peas during 1946–1947. The main data was obtained from samples ef vines and peas taken in experimental plots at Beaver Dam and Waunakee, Wisconsin, treated with dusts containing from 1 to 5% DDT. Simultaneously milk samples from cows fed with DDT silage were also analyzed.

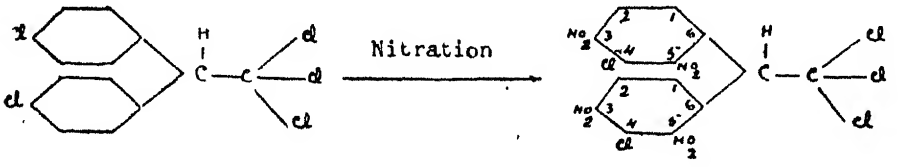
In all these determinations Schechter *et al* method was followed both for fatty (milk) and non-fatty (pea vine silage) materials.

Biological assay method and all the Chlorine determinations ran into great difficulty when the amount of DDT was less than about 1 mg. and they lacked specificity too. Chaikin colorimetric determination of p,p'-DDT provided with an accuracy upto 1% only. Stiff and Castillo's method was interfered by the presence of sulfur in spray mixtures and 18 analogs including derivatives of DDT also produced the similar colour, thus this method also lacked specificity. Friedel and Craft reaction of Bailes and Pyane still subject for further investigation as to interference caused by other materials present in the spray of dust

residues. The method of Jones had been used for the determination of DDT in smokes. In the method of Bradbury *et al* there was a standard deviation of only 0·5% between found and known results and therefore it needed further investigation.

Method of Schechter *et al.*, :

The method was based on intensive nitration of DDT present in plant or animal materials to polynitro derivatives and the production of intense colours upon addition of methanolic sodium methylate to a benzene solution of the nitration products.



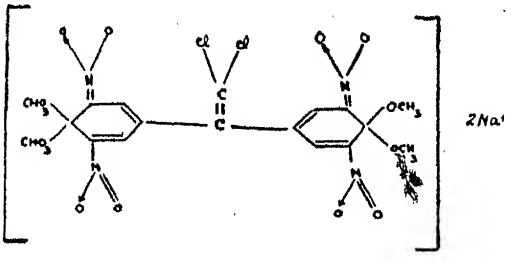
p—p'—DDT

2, 2, bis—'4 chloro—3, 5—dinitrophenyl) —I, 1, 1, —trichloroethane

Spectrophotometric data :

p,p'-DDT gave blue colors with maximum absorption at 600 mμ (wave length) and minimum absorption at 443 m μ and o,p'-DDT gives a violet red color with two maximum absorption at 590 and 511 mμ and minimum absorption at 558 and 426 mμ upon the addition of methanolic sodium methylate to a benzene solution of the nitration products.

The blue color in the case of p,p'-DDT might be due to the following type of reaction product.



Apparatus :

Glass-beads (2 or 3 mm.) test tubes (22×175 mm.) with rims, separatory funnels (225 ml. capacity) and Glass Gooch-crucible holders (body about 25 mm. in diameter and about 75 mm. stems and long stem about 30 mm. long).

Solvents and regents :

1. Nitrating acid-Mixture of C. P. fuming nitric acid and C. P. Conc. H_2SO_4, 1 to 1 by volume.
2. Sodium hydroxide solution 2%

3. Sodium chloride solution—c. p. NaCl saturated in distilled water
4. Cotton extracted with acetone
5. Ether-distilled before use
6. Benzene, C. P. dry—(thiophene free)
7. Sodium methylate solution, 10·0±0·1%, chemically pure
8. Acetone-redistilled before use.

Procedure :

Extraction of DDT from samples.—Completely dried material was weighed in a thimble and DDT was extracted with acetone in the 'Gold fish extractors" or "Soxhlet extractor" for 24 hours. The acetone was evaporated using a glass bead and vacuum. The residue was dissolved in 150 ml. of chloroform and was extracted with 50 ml. of Na_2SO_4-H_2SO_4 (10 gm of anhydrous Na_2SO_4 dissolved in 10 ml. of conc. H_2SO_4) twice, then with 50 ml. of mixture of equal parts of fuming H_2SO_4- Conc. H_2SO_4 and lastly again extracted with 50 ml. of H_2SO_4 $NaSO_4$ twice. The extracted chloroform solution was poured into 500 ml. separatory funnel through a 5 c.m. plug of cotton. Now 20-40 ml. of 5% Na_2CO_3 solution was added to make the solution alkaline. The solution was filtered through a plug of cotton and was evaporated until about 10 ml. of this solution had remained. The remaining 10 ml. solution was washed quantitatively into a test tube and was evaporated using a glass bead on a steam bath.

Nitration of sample.—The test tube was cooled in a beaker of cold water and with a pipet 5 ml. of the nitrating acid was added. The test tube now was immersed about one third its length in a steam bath and was heated for 1 hour. After one hour nitration the test tube was cooled again in a beaker of cold water and 25 ml. of ice cold distilled water was added by gentle swirling.

Extraction of nitrated product.—The contents of the test tube were transferred quantitively into a 125 ml. separatory funnel with 25 ml. of water and 50 ml. of ether. After a vigorous shaking for a minute the lower layer was drawn off and discarded. The ether layer was washed with 10 ml. portions of 2% aqueous NaoH (at least twice) until washing were alkaline. Then the ether solution was washed with two 10 ml. portions of salt solution and finally the ether solution was filtered slowly through a plug of cotton packed lightly in a glass Goochcrucible holder into a 125 ml. Erlenmeyer flask. The separatory funnel was rinsed four times with 50 ml. of ether. The ether solution was allowed to evaporate in the Erlenmeyers flask with a glass bead in it and after all the ether had apparently evaporated, a glass tube was inserted connected to a source of vaccum for a minute to romove the last traces of the ether.

Development of colour.—10 ml. of benzene (thiophene free) was accurately added to the residue in the Erlenmeyer flask and was swirled gently until it was dissolved. From the solution exactly 5 ml. was pipeted into an Evelyn tube and 10 ml. of sodium methylate reagent (chilled in cold for a day) was added. The mixture was shaken until the solution became homogenous. After 15 minutes the Evelyn tube was placed into the tube of the photometer and photometric measurement was taken using 580 mμ filter. In case the colour was too deep, an aliquot of the remaining benzene solution was taken and treated exactly as above.

With every sample of analysis a blank was always run on a sample of same type of material analyzed which had not been treated with DDT.

Observations :

Pea vines at the time of treatment with DDT.—In the experimental field at Waunakee the vines were treated at the blossom stage 12 to 14 inches high. When the field was cut the vines average 24 inches in height and the pods were all formed on the upper 6 to 8 inches of the stem having approximately 10 inches on which the DDT residues might remain. The pods and stems make up the greater portion of the silage so it may be safely estimated that less than 50% of the vine growth had been exposed to DDT.

At Beaver Dam the vines of the larger vine type (Prince of Wales) averaged 42 inches in length, DDT was restricted to the lower 18 inches of vine growth. Here again the leaves had dropped from the lower 8 to 10 inches of the stem and not more than 10 inches of the vine growth could have contained any DDT residues. In this case much less than 50% of the vine growth could have carried any DDT. Only a relatively small amount of this actually clings to the vines immediately after the dust was applied. The types of dust used and rate of application are shown in Table 1.

TABLE 1

DDT dusts applied to canning peas in 1946 and rate of application

Location	% DDT	% Solvent	% Rotinone	Lbs. per acre
Beaver Dam	1	3[1]	0·5	40
,,	2	3[1]	0·25	40
,,	2·5	2[2]	—	40
,,	3	2[2]	—	40
,,	5	—	—	40
Waunakee	3	3[1]	—	35
,,	5	—	—	35-40

NOTE 1. One-half propylene laurate and one-half SAE 10 lubricating oil.
2. Yarmor pine oil.

Results :

DDT on pea vines.—DDT residues were found on pea vines treated with dusts containing from 1 to 5% DDT at 40 lbs. per acre. When these dusts were applied on the experimental plots at Beaver Dam, with a ground machine, the residues ran from 2 to 6 ppm at the time of application on June 13. On June 26 one sample from a 5% plot showed 3 ppm. and another sample taken July 6 showed 4 ppm. At Waunakee dusts containing 3 to 5% DDT were put on with a ground machine at 35 lbs. per acre for the 3% dust and at 35 and 50 lbs. for the 5% dust. One sample of vines treated with a 5% DDT dust at 36 lbs. per acre on June 12 showed 2 ppm. on June 29. Two other samples collected on July 5 and 6 showed 3 ppm. A sample of vines treated with 50 lbs. per acre of 5% DDT dust on June 22 and collected immediately after treatment showed 9 to 13 ppm. A sample of silage from this area taken from the stock on October 10 showed only 5 ppm. (Table 2.)

TABLE 2

Samples of vines taken immediately and at later dates after treatment had been made with a ground machine (1946)

Source of material	lbs. per acre	% DDT	Date of treatment	Date of sample	ppm. DDT found
1. Beaver Dam	40	1	June 13	June 13	3
2. ,,	40	2	,, 13	,, 13	2
3. ,,	40	2·5	,, 13	,, 13	5
4. ,,	40	3·0	,, 13	,, 13	5
5. ,,	40	5·0	,, 13	,, 13	6
6. ,,	40	5·0	,, 13	,, 26	3
7. ,,	Nil	Control	,, 13	,, 11	0
8. ,,	40	5·0	,, 13	July 6	4
9. Waunakee 1st planting	35	5·0	,, 22	June 29	4
10. Waunakee vines from 1st planting	35	5·0	,, 22	July 6	2
11. Waunakee vines from 2nd planting	50	5·0	,, 22	June 22	9-13
12. Waunakee vines from 2nd planting	35	5·0	,, 22	July 5	3

Dust containing 3 to 5% DDT applied by airplane at 35—40 lbs. per acre gave residues of 2 and 3 ppm. (Table 3).

TABLE 3

Samples of vines taken immediately and at later dates after treatments had been applied by airplanes (1946)

Source of sample	lbs. per acre	% DDT	Date of treatment	Date of sample	DDT found ppm.
1. Beaver Dam	40	3	June 23	June 25	2
2. ,,	40	5	,,	,, 25	3
3. ,,	40	5	,,	,, 29	2
4. ,,	40	5	,,	,, 25	3
5. ,,	35	3	,,	July 6	3·1

2. *DDT on shelled and canned peas.*—No DDT was found in any sample of peas shelled by hand or in the Viner (Table 4).

TABLE 4

Samples of peas shelled by hand in the field at time of cutting and canned peas

Source of sample	Lbs. per acre	% DDT	DDT found ppm.
Shelled peas			
1. Beaver Dam	40	5	0
2. ,,	40	5	0
3. Waunakee from viner	35	5	0
4. ,, ,,	35	5	0
5. Waunakee shelled peas	35	5	0
Canned peas			
6. Beavar Dam airplane	40	3	0
7. ,, ,,	40	5	0
8. ,, ,,	control	0	0
9. Waunakee ground machine	35	3	0
10. ,, ,,	35	5	0
11. ,, ,,	35	5	0

DDT in Silage.—At Waunakee samples of vines treated with 50 lbs. per acre of a 5% dust taken immediately after the treatment was applied showed 9 to 13 ppm. Samples of the same vines taken at the top and near the outside of the silage stack on September 5, October 10, and November 8, 1946 showed 5 to 7, 5, and 4 ppm. respectively. Samples of vines treated with 35 lbs. of 5% dust showed 3·6 ppm. of DDT when put into the silage stock.

The first samples of silage from within the stack were taken on November 16 by means of a three foot auger forced into the stack beyond the rotted outer layer which was about a foot to 18 inches thick. Additional samples were taken from inside the stack after portions of the silage had been removed. In removing the silage the operation started from one side of the stack and sections three to four feet wide (for the depth of the stack) were removed. This provided wide faces or walls from which samples could be taken. The set of samples collected on January 16 were from a face about 8 feet inside the stack and about 6 feet from the bottom. Samples collected on February 15 were taken from wall 10 feet inside the stack, 2 feet above a layer of straw under the stack and 2 feet apart in cuts 12 inches high.

The reported DDT residue for each sample of silage from September 5 to February 15 are given in table 5.

TABLE 5

DDT residues in sample of silage from vines treated with 3 and 5% DDT dusts. Vines placed in stack between July 2 and 9, 1946

Sample No.	Date	Source	% DDT dust	lbs. per acre	DDT ppm.
1.	September 5	Top stack	5	50	5·7
2.	October 10	2 feet inside stack	5	50	5·0
3.	November 8	18 inches inside stack	5	50	4·0
4.	,, 16	Taken by auger about 3 feet in stack	5	35	3·0
5.	,, 16	Taken by auger about 3 feet in stack	3	35	3·0
6.	,, 16	From silage stack	(DDT none)	—	2·0
7.	January 15	From load of silage for feeding test	5	35	Heavy ppt. (No apparent DDT)
8.	,, 16	From face of stack	5	35	1·4
9.	,, 16	,,	5	35	1·0
10.	,, 16	,,	3	35	1·0*
11.	,, 16	,,	3	35	1·0*
12.	,, 16	Widely separated stack	(No DDT)	—	0·8*
13.	,, 16	,,	,,	—	1·0*
14.	February 15	2 ft. above bottom of silage	5	35	0·9*
15.	,, 15	,,	5	35	1·2*
16.	,, 15	,,	5	35	1·1*
17.	,, 15	,,	5	35	0·7*
18.	,, 15	From wall in 3% DDT stack	3	35	0·3*
19.	,, 15	,,	3	35	0·7*
20.	,, 15	,,	3	35	0·7*

NOTE —*No blue colour detectable. Absorption is due to brown colour produced by sodium methylate. None of the samples showing turbidity had any detectable blue colour, but there is a slight possibility that such precipitate include the coloured materials.

Conclusion.—In the samples analyzed, a decrease of DDT residues in the stacked silage can be noted. In the three samples taken from vines treated with 50 lbs per acre of 5 % DDT dust, the DDT residues show a decrease between October 10 and November 8.

In the samples treated with 35 lbs. per acre of 5% DDT dust the vines showed 3·6 ppm. of DDT when put into the stack and 3 ppm. in the silage on November 16. By January 16 only 1·4 ppm. could be found in silage from the 5% dust and 1 ppm. in the 3% DDT treated silage.

Sources of samples.—Samples of pea vines had been taken from fields just after dusting, then collected at intervals, at the time of harvesting and finally from the stacked silage.

Conclusion :

DDT in pea vines.—DDT residues on fresh pea vines treated with DDT dusts containing from 1 to 5% found to vary from 2 to 6 ppm. when dusted with ground machine on June 13, 1946 at Beaver Dam. On June 26 and July 5 the samples were taken from plots dusted with 5% DDT at 40 lbs. per acre and these showed 3 and 4 ppm. of DDT respectively.

At Waunakee the 5% DDT dusts was applied on 22nd June, 1946 at 35 lbs. per acre. A sample taken on June 26 showed only 2 ppm. of DDT and on July 6 another sample was taken just after 5% DDT dust was applied on June at 50 lbs. per acre and it was found to contain 9-13 ppm. This sample was specially collected from the heavily dusted place. Another sample taken on July 5th from the 2nd planting dusted with 5% DDT at 35 lbs. per acre on June 22nd showed 3 ppm.

At Beaver Dam the pea fields were dusted with 2 to 5% DDT dust at 35–40 lbs. per acre by airplane on June 23 The samples were collected on June 25, 29 and July 6 and they were found to contain 2 to 3·1 ppm. of DDT.

DDT in silage.—The vines treated with 5% DDT dust at 50 lbs. per acre were placed in stack between July 2 and 9, 1946. These vines during the time of treatment (on June 22, 1946) on analysis gave 9–13 ppm. of DDT. Now after they were stacked, samples of the same vines were taken out from the top and outside of the silage stack on September 5, October 10 and November 8, 1946 and showed 5–7, 5 and 4 ppm. respectively. Vines treated with 35 lbs. per acre of 3 and 5% DDT dust showed 3·6 ppm. when put into stack on November 16.

Later on samples from this silage stack were taken on January 15 and 16 and several samples on February 15. All these samples on analysis were found to have 1·4 to 0·3 ppm. Check samples which received no DDT treatment, showed colorimetric reading equivalent to 0·8 ppm., so it appeared that the DDT residue in all these sample after November 16 was below than 1 ppm. In these samples no detectable blue colour was visible. The absoprtion was probably due to brown colour produced by sodium methylate. There was slight possibility that such precipitations inhibit a very faint blue colour. In surveying the whole field of DDT residues present in pea vines from the time of dusting till the consolidation of silage stack, it was concluded that the amount of DDT was reduced from 9–13 ppm. to 0·3 ppm. within a period of 8 months from June 13 to February 15, 1946. Thus the hazard of feeding DDT treated silage to the cows seemed to converge to the minimum.

Results of feeding tests with cows fed on silage from vines treated with 5% DDT.—To investigate the amount of DDT present in the silage might accumulate in the milk of cows, five cows starting November 15, 1946 were placed on rations containing pea vine silage from the reported silage stack. The daily ration of silage for the cows from November 15 to March 31, 1947 was 3% of the body weight averaging 37 pounds. Between February 15, 1947 and March 31, seven milk samples from cows were analyzed after Schechter *et al.* method.

Procedure of analysis.—100 grams of milk were thoroughly mixed and an equal volume of 95% ethanol was added. The solution was divided equally between 200 ml. centrifuge bottles. 50 ml. of Skellysolve B was then added to each bottle. The bottles were covered with rubber caps, shaken vigrously and centrifuged at 2000 r. p. m. for 15 minutes. The contents of both bottles were poured into a 500 ml. separatory funnel, and after the layers had separated, the lower layer was drained in equal proportions directly into the same centrifuge bottles, while the upper Skellysolve B layer was drained through a 5 cm. tightly

packed plug of cotton held in a glass Gooch crucible holder into a 500 ml. Erlenmeyer flask with a standard ground glass joint. The solution in each centrifgue bottle was extracted in the same manner as before with two successive 25 ml. portion of Skellysolve B and a final 50 ml. portion centrifuging for about 10 minutes each time. The lower layers were returned from the separatory funnel to the centrifuge bottles and filtered the upper layers through the plug of cotton into the Erlenmeyer flask. After the last extraction the separatory funnel was rinsed with 50 ml. of Skellysolve B, which was run also through the plug of cotton into the Erlenmeyer flask. By additing a glass bead, evaporated Skellysolve B and finally last traces of the solvent were removed by inserting a tube connected to a vaccum. The analysis was completed as described for the pea vines and silage.

Result :

Samples of milk taken from cows receiving no DDT give colorimetric reading of approximately 0·2 ppm If this amount is deducted from the above readings, the maximum amount of DDT present in a single sample was 0·4 ppm but a sample taken from the cow on a later date showed only 0·14 ppm In either case the residues are so small that no health hazard would seem to exist from using or drinking the milk.

The results of the analysis of 7 milk samples are shown in Table 6

TAALE 6

Reported analysis of milk samples taken from cows feeding on silage from vines treated with 5% DDT

Cow No.	Date of Sample	DDT ppm. colorimetric reading
500	February 15	0·5
2 A	February 28	0·2
6 H	February 28	0·2
500	February 28	0·2
241	March 26	0·5
500	March 26	0·6
183 (colostrum)	March 31	0·34
Check	(no DDT) February 28 and March 26	0·2

Summary :

1. Pea vine silage from pea vines treated in the field with one application of per cent or 5 per cent dust showed definite quantities of DDT residues when ensilaged.
2. A noticeable decrease in DDT residues in silage developed over a period of four months. The decrease being from an original residues content of 5 to 7 ppm. to an average of approximately 1 ppm.
3. When dairy cows fed on average daily ration of 37 pounds of DDT treated silage for a period of five months, the DDT residues in milk, were relatively small.

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STUDIES ON FISH AND FISHERIES OF THE GODAVARY AND THE KRISHNA RIVER SYSTEMS—PART I*

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FISH AND FISHERIES

Introduction :

The status of the fishing industry and the nature of fish fauna within the main Godavary and the Krishna rivers and their tributaries are still inadequately understood and the exploitable potentialities largely unassessed. The few available records refer mainly to taxonomic accounts of fish obtained at random, rather than to fishery management. At the instance of the Director of this Institute, the author undertook a survey of the middle reaches of the two rivers in the Andhra Pradesh region during February—March 1958. A suitable site was also to be recommended on one of the two rivers for locating a unit of this Institute for fishery biological studies considering availability of adequately large number of fish samples over a major part of the year. Results incorporating earlier records of fish fauna within the drainage are presented in this contrition. Based on this it may perhaps be possible to plan further research which may lead ultimately to more scientific management and exploitation of both water sheds.

Physical Features and Steam-flow Characteristics :

The Godavary.—The Godavry river is about 900 miles long from its origin in the northern region of the Western-ghats at elevations of 4,000–5,000 feet, in the Deolali hills near Nasik to its tidal limits below Rajahmundry in Andhra Pradesh, and is one of the four major rivers of the East Coast of India draining into the Bay of Bengal (Fig. 1). Its catchment area is 1,22,000 sq. miles. Main tributaries of the Godavary are the Manjira, Waingunga (with its secondary tributaries—Paingunga and Wardha) and the Indravati. Minor tributaries are the Purna, Maner, Sabari and a host of rivulets and seasonally active streams. Except for the Indravati and the Sabari which originate in the Eastern-ghats at elevations of 2,500–4,000 feet, all tributaries drain comparatively a dry region of the Deccan Peninsula south of Nagpur in Central India or the wet slopes of the Western-ghat ranges. All Deccan rivers are entirely fed by seasonal rains as the hill ranges of their origin are low with an average height of 3,000 feet. More than 90% of the year's run-off in the catchment occurs between May and October during the South-West monsoon rains. Mean temperature in the water-shed is about 82°F and the mean humidity ranges between 60 and 70%. The Eastern-face of the Western-ghats are densely forested with perennial hill streams in Maharashtra and Mysore States where as much as 200 inches of rain per year has been recorded in parts of the catchment. Between 30 and 50 inches of rain-fall occurs in the middle and lower reaches of the Godavary. The Eastern-ghat hills are also comparatively wet, but the tributaries here are much less important than Western-ghats in the variety of fish-fauna.

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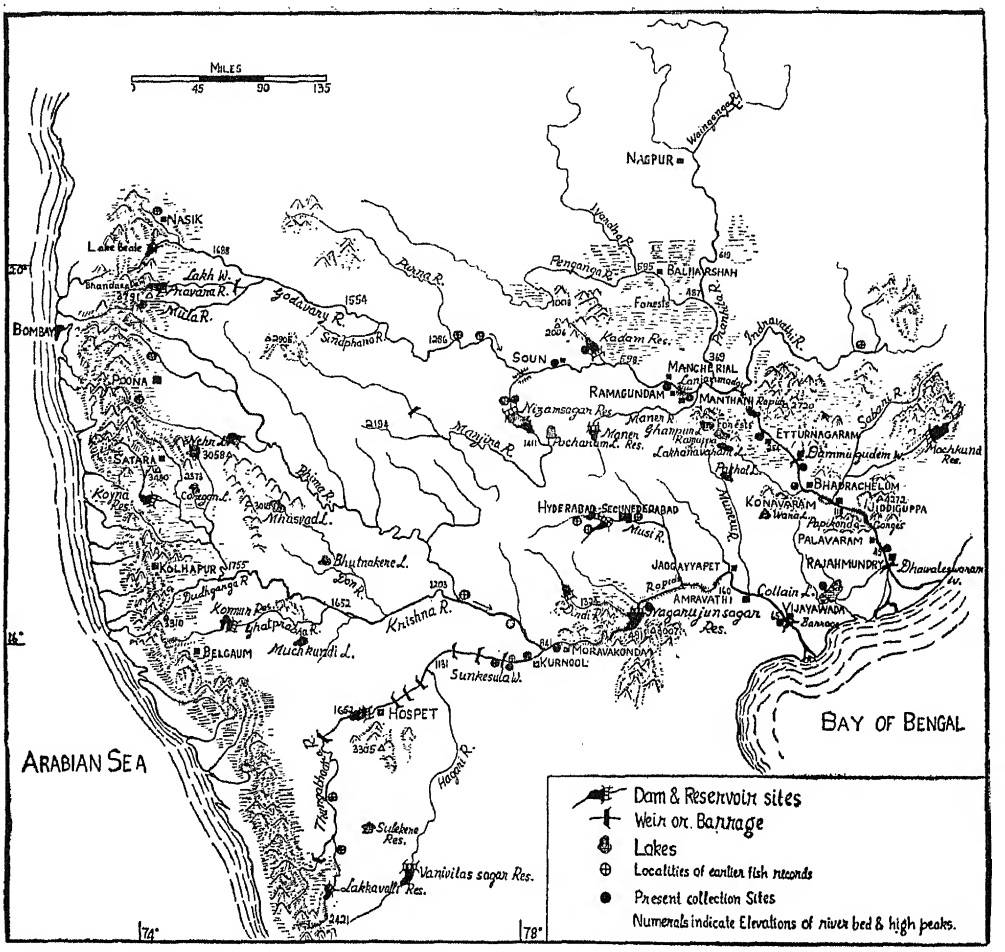

Map showing the Godavary and Krishna drainages, with the tributaries, important locations of towns etc. Dam and reservoir sites, weirs and barrages, natural or semi-natural lakes, localities of earlier fish-records, present collection sites and the deeper gorges and pools which offer all the year round shelter to fish, are indicated.

Descending from 5,000 to 56 feet elevations from origin to its emergence into a short deltaic stretch, and flowing through mainly a sub-stratum of gneissic rocks in the Peninsular highlands, the whole length of the Godavary is swift flowing, eroding the rugged plateau forming numerous pools and rapids in its torrential course. Its slope varies between 2 and 5 feet per mile but in some tributaries as much as 8 feet. Western and near Eastern catchment is flanked by forested tracts, and subjected to limited erosion but the middle course lies within open rolling country whose rich black soil is intensely cultivated. The river has cut deep into the basaltic rock, forming high banks of 15–30 feet, but though torrential during monsoon, never overflows its banks except in its delta near Rajahmundry.

The river bed in the middle reaches has a disproportionately thin stream of water coursing through narrow, broken up channels between rocks or interspersed with wide sandy stretches. Isolated rocky pools and shallower sandy channels are common and one can easily wade across the river as far as Manthani (Fig. 1) during dry months. Deep rocky or silty shelters known locally (in Telugu) as "madgu's" which during dry months protect large sized fish, are found at frequent intervals along the river. One such shelter, nearly a mile in length, is found at the confluence of the Manjrra with the Godavary in Nizamabad district and the second, over 3 miles in length, known as "Lanjan Madgu" is close to Manthani. Thereafter the river courses over rapids through a very sparsely inhabited forest region, occasionally broken by minor tributary valleys as far as Etturnagaram in Warangal district. Here the river sprawls nearly 3 miles over a sandy and silty stretch forming several muddy islands between low embankments. At Dummu_ulem and Bhadrachellum weir sites, the river again narrows to about a mile, with the stream confined between rocky outcrops forming a number of small "madgus" up to Konavaram. In the 30 miles long Papikonda gorges (spurs of Eastern-ghats) the course is channelled to less than 100 yards in width between rocky cliffs rising abruptly several hundred feet from the surface of water. Depths are as much as 200 feet, but the slope only $1\frac{1}{2}$ feet per mile. Emerging from the gorges, the river spreads over its flat deltaic area, where it widens to 2 to 3 miles into a sand and silt-spread course. At Dhawaleswaram weir site, the bed is 5 miles wide. No water is allowed into the estuary 30 miles below for 7–8 months during dry months, cutting off the main flow with the estuary.

Two weirs, at Dhawaleswaram for irrigation and navigation and at Dummugudem for navigation, have been built. No major dams exist on the main Godavary as yet, but the lake Beale formed by a dam in Nasik district across a small tributary, the Bhandardar dam (270 feet high) on the Pravara, the Lloyd dam at Bhatgarh on the Nira and the Whiting Lake are some of the high masonry dams in the Western-ghat headwaters. The Manjira, Maner, Kadam and Machkund rivers have each a major high dam forming large reservoirs of from 10 to 50 sq. miles Besides, a number of weirs also exist in drier areas of Madhya Pradesh and Maharashtra on the minor rivulets. Even though, the above dams and weirs are of comparatively modern designs, irrigational tanks of a capacity of a few acres to several square miles of water spread, constructed of stone or even of mud centuries ago, are characteristic of Andhra Pradesh, Maharashtra, Madhya Pradesh, Mysore and Madras States in Deccan. All these are designed to impound seasonal monsoon run-offs through smaller rivulets to tide over prolonged dry spells. But for their utility in irrigation, major tracts of Deccan would otherwise remain mainly dry. Spills from these tanks and reservoirs connect ultimately one or the other river system during rains. There are more than 100,000 major and minor tanks and reservoirs in the water sheds of these two rivers.

Hundreds of miles of irrigational canals exist in the Godavary water-shed of which those taking off from Dhawaleswaram weir and Nizamsagar are of immense importance. No 'jheels' or 'bheels' as in the low-lying Ganga-Brahmaputra systems can form in the Deccan terrain, but the spillways from tanks and reservoirs afford easy ingress and egress for fish to distribute over a wide range.

The Krishna —The Krishna river has a length of nearly 700 miles from its origin in the 4,000-5000 feet high Western-ghat ranges south of Poona, as far as Vijaywada almost at sea-level near its delta on the East-Coast (Fig. 1). Main tributaries are the Bhima which originates north of Poona district and the Thunga-bhadra formed by the twin rivers—the Thunga and the Bhadra, both arising in Mysore at elevations of 5,000–6,000 feet. Both tributaries confluence with the Krishna near the border of Andhra Pradesh at elevations of 1,300 and 1,000 feet respectively in the wide, shelving plains. The Bhima is almost a dry river during summer months while the Thunga-bhadra is perennial with a greater volume of flow than the main Krishna itself Conditions of flow, nature of river bed and other features are very similar to that of the Godavary system as the two water-sheds are contiguous over the major terrain of the Deccan Plateau ; the catchment of the Krishna system is 90,050 sq. miles, consisting of thick forests in the hilly regions of the Western-ghats with over 300 inches of rainfall in some pockets, and intensely cultivated open fields in the dry, middle plains.

Maximum flood discharge recorded at Vijaywada is 1,190,000 cusecs and the minimum about 300 cusecs. Shelters and "madgus" in the Krishna are smaller than in the Godavary, but the Thunga-bhadra is by far richer in pools and rapids, but above Kurnool it is mainly sandy for 70–80 miles. For a distance of nearly 170 miles above Vijaywada, the Krishna descends 5 feet per mile over an underdeveloped rough, hilly forest tract through rapids of the Nallamalai hills which are the southern-most spurs of the Eastern-ghats.

Major reservoirs formed of high dams within the Krishna drainage are the Lakkavalli reservoir on the Bhadra, the Thunga-bhadra reservoir, the Koyna, Vanivilassagar and a few more on the Mutha, Ghataprabha and other minor tributaries (Fig. 1). Several reservoirs are formed by masonry dams around Hyderabad City across the Musi and the Easi rivers or minor nullahas (*e.g.* the Himmatsagar, Osmansagar Hussainsagar, Meer-Alum tank and Ibrahimpaton tank varying from 5–26 miles in spread). A number of anicuts (weirs) on the Thunga-bhadra and the Bhima, serve irrigational needs of the dry belt. Minor impoundments are also found within the headwater streams. A weir across the Krishna at Vijaywada 50 miles from its mouth, recently damaged by floods, is now replaced by a barrage. Almost the entire amount of impounded water is diverted for irrigation, allowing no water into the bed below to connect the tidal mouth some 35 miles from the barrage site during dry months.

The water-shed is equally rich in tanks and small irrigational reservoirs which spill during monsoon into one or the other river finally joining the main Krishna. The canal systems of both river weirs at Rajahmundry and Vijaywada are interconnected near Ellore and the marshy freshwater Collair lake (100 sq. miles in area) sustaining a rich, stagnant water fish population, is formed by the monsoon overflows of both the rivers.

Fishes :

A systematic List of Fishes.—A list of identified fishes of both drainages recorded up-to-date by several earlier observers and by the author during the survey is given on page 13. A total of 155 species belonging to 61 genera and 24 families

are so far known from the two adjacent water-sheds of which at least 92 species are common to both. The author recorded 102 species in the present collection and has included 53 species credited to earlier recorders as mentioned against such species. It is noteworthy that Annandale (1921), Hora and Misra (1938), Fraser (1942) and Hora and Misra (1942) recorded fishes from the head-waters of both river systems. Similarly Bhimachar and Rao (1942) and David (1957) have listed fishes of the Thunga and the Bhadra rivers. All other records by Rahimullah (1943, 1943*a* and 1944), Mahmood and Rahimullah (1947*a*) and Chacko and Kuriyan (1948) and the present record by the author refer to fishes within the middle reaches. The fishes of the lower estuarine regions however remain unrecorded.

Several forms are also recorded from tanks of either drainage. No specific fish record from the isolated pools of the Western or the Eastern-ghat hill ranges, is actually available even though zoo-geographically very interesting forms are suspected in them.

Amongst the stagnant tank forms, the genera *Amblypharyngodon*, *Puntius*, *Ompok*, *Mystus*, *Heteropneustes*, *Clarias*, *Oryzias*, *Channa*, *Anabas* or *Colisa*, may be mentioned ; they sometimes also occur in small streams and isolated muddy pools of the rivers as well. *Oryzias melanostigma*, *Nandus nandus*, *Anabas testudiens* and *Colisa fasciatus* are recorded by the author from the Collair lake only.

Economic species—Ecological and hydrological features in the two water-sheds preclude possibilities of occurrence of most larger forms, because the fish sustaining capacity of the rivers in their entire lengths, is greatly limited as already described. Bigger forms frequent large stony pools and rapids during major part of the year ; but the shallow sandy areas are more or less completely denuded of large fish by intense fishing. Medium and small sized species abound in the major lengths of the rivers, and the unfished forest tracts and gorges seem to afford a natural protection to the fish stocks. Within the short deltaic stretches above Rajahmundry and Vijaywada, ecological conditions have proved congenial for several species considered essentially rapid or torrential ; probably their young drift down from the rapids some distance above, and find adequate food in the impoundments.

The following are some species considered economical for reasons given :

Major forms attaining 20" (approximately 500 mm.) and above :

1. *Hilsa ilisha* (Ham.) — Provides the largest commercial fishery of any single species ; ascends up to Bhadrachellum in the Godavary and some distance above Vijaywada in the Krishna.
2. *Catla catla* (Ham.) — Does not appear to frequent rivers above an elevation of 1,200 feet ; prominent in lower reaches below dams, weirs and also in Collair lake.
3. *Cirrhina mrigala* (Ham.) — Transplanted and now acclimatised in lower reaches. A semi-economic form at Rajahmundry and Vijaywada and prominent in Collair lake.
4. *Labeo calbasu* (Ham.)
5. *Labeo fimbriatus* (Bloch). — Dominant species in both river systems, but *L. fimbriatus* is the most important species in upper and middle reaches.

6.	*Labeo gonius* (Ham.)	Mainly in lower reaches.
7.	*Labeo Pangusia* (Ham.)	Recorded near Dummugudem ; suspected in the Thunga-bhadra.
8.	*Labeo porcellus* (Haeckel)	Frequent in rocky pools and rapids in all rivers.
9.	*Labeo potail* (Sykes)	
10.	*Labeo rohita* (Ham.)	Transplanted into lower reaches, marketed in quantities from the Collair lake.
11.	*Puntius kolus* (Sykes)	Abundant throughout the two river systems.
12.	*Puntius pulchellus* (Day) =*P. jerdoni* (Day)	Common in the upper and middle reaches, rare except as young in the lower.
13.	*Tor khudree* (Sykes)	Upper and middle reaches inhabited largely by these Mahseers; young occur in lower reaches.
14.	*Tor mussullah* (Sykes)	
15.	*Tor* (?) *neilli* (Day)	Recorded so far only in the Thunga-bhadra.
16.	*Wallago attu* (Bl. and Schn.)	Common throughout the two water-sheds.
17.	*Mystus aor* (Ham.)	Frequent in all the rivers.
18.	*Mystus seenghala* (Sykes)	
19.	*Bagarius bagarius* (Ham.)	Caught in all head-waters and middle reaches ; young occur in lower reaches.
20.	*Silonia childrenii* (Sykes)	Recorded in middle reaches, more frequent in the lower.
21.	*Pangasius pangasius* sub-species *godavarii* nov.	Recorded in deep middle reaches, common in lower deltaic regions.
22.	*Anguilla bengalensis* (Gray)	Frequents crevices in rocks, entering tanks.

Medium sized species between 10–18" (250–450 mms. approximately)

23.	*Cirrhina reba* (Ham.)	Common to both river systems.
24.	*Labeo bata* (Ham.)	Extensively captured in sheltered rocky shallows and rapids, prominent in lower reaches.
25.	*Labeo boga* (Ham.)	
26.	*Labeo boggut* (Sykes)	
27.	*Osteobrama belangerii* (Cuv. and Val.)	Common throughout the two rivers.
28.	*Puntius curmuca* (Ham.)	Recorded within the Thunga-bhadra sub-drainage and headwaters within Western-ghat streams.
29.	*Puntius lithopidos* (Day)	
30.	*Puntius sarana* (Ham.)	All through the drainages.
31.	*Schizomatorhynchus nukta* (Sykes)	Common in rapids of both river systems.
32.	*Thynnichthys sandkhol* (Sykes)	Frequent in both rivers in pools below rapids.
33.	*Ompok bimaculatus* (Bloch)	Large numbers occur in weedy and muddy pools in rivers and tanks of the drainages.
34.	*Rita pavimentata* (Val.)	Common in rivers.
35.	*Proeutropiichthys taakree* (Sykes)	Known from all streams and rivers of the two systems.

36.	*Glossogobius giuris* (Ham.)	Common in the entire drainages.
37.	*Macrognathus aculeata* (Bloch)	Throughout the drainages within the rocky and weedy shelters.
38.	*Mastacembelus armatus* (Lacépède)	
39.	*Mastacembelus pancalus* (Ham.)	

Small sized species under 10" (250 mms. approximately) in size.

40.	*Oxygaster clupeoides* (Ham.)	Occur in profitable numbers in all the main running waters.
41.	*Oxygaster phulo* (Ham.)	
42.	*Aspidoparia morar* (Ham.)	
43.	*Osteobrama vigorsii* (Sykes)	
44.	*Puntius amphibius* (Cuv. and Val.)	Available in large numbers in sandy and muddy shallows in all rivers.
45.	*Mystus gulio* (Ham.)	Occurs close to the estuary near weirs.
46.	*Mystus vittatus* (Bloch)	Common in the entire two water-sheds.
47.	*Rita hastata* (Val.)	Frequent in the main and tributary rivers.

Further investigations can assess the species abundance in each section of the main or tributary rivers. Species distributed from the remotest head-waters to the lower deltaic regions is however *L. fimbriatus*, closely followed by *L. potail*, *L. porcellus* and some medium sized Labeos. *L. calbasu* is not very abundant. *Puntius kolus*, *P. jerdoni* (=*P. dobsonii*), *Tor* spp. *Schizmatorhynchus nukta*, *Bagarius bagarius*, *Mystus aor*, and *M. seenghala* are some of the large species occurring in the numerous rocky and stony shelters. *Wallago attu* is found everywhere. Sandy stretches are generally populated by small forms as already mentioned. In the deltaic reaches, *Cirrhina mrigala*, *Labeo rohita*, *Silonia childrenii*, *Pangasius pangasius* and some estuarine forms are fished ; besides, *Hilsa ilisha* is a major fishery during monsoon floods. Estuarine forms like *Mugil parsia*, *Pama pama*, *Leiognathus equulus* and others noted at Rajahmundry and Vijaywada, are stranded adults or juveniles from the estuary confined to freshwaters soon after the monsoon when connection between the estuary and the river above is severed. Young *Hilsa* are also caught.

Species of *Gadusia*, *Esomus*, *Rasbora*, *Amblypharangodon*, *Osteochilus*, *Lepidocephalichythys*, *Ompok*, *Heteropneustes*, *Clarias*, *Channa*, *Anabas* or *Awous* colonise parts of river streams, or occur in tanks proving of economical value in most places.

Beside the above fishes, the freshwater prawns—*Palaemon malcolmsonii* and *P. carcinus* occur all along the Godavary but are scarce in the Krishna river except in the lower reaches.

Fisheries and Fishing Industry :

Fish Landings.—A production of about 36 lbs. per acre sheet of water has been computed from the Nizamsagar reservoir annually. Species of *Labeo Puntius*, *Cirrhina*, *Catla*, *Thynnichthys* and a number of catfishes and Murrels are available within the reservoir. As no fish can move upstream into the reservoir even during the surplus discharge, the fish landed from the reservoir, are from a confined stock that can only originate in the Manjira up to Ghanpoor weir. About 20–30 tons of standed fish are annually caught below the Nizamsagar during

monsoon at the time of surplus discharge. Normally only few fish are caught here. At Dudgaon--Soun bridge site, eight cast net fishermen had caught nearly 70 lbs. of fish and prawns during two hours night fishing. *Labeo* sp., *Puntius kolus*, *Mystus* sp., *Ompok* spp. and *Wallago attu* predominated but nearly 30 lbs. of the catch consisted of sprawns--*Palaemon malcolmsonii*, *P. carcinus*, etc At Ramagundem—Mancherial stretch fish captured in the course of half a day in the fixed traps "Eduthorakkalu", were estimated at about 90 lbs., which included *Puntius* spp., Mahseers, *Barilius* spp., *Oxygaster* spp. and *Mystus* sp. with some minor forms.

400–500 lbs. of fish are caught on days when the drag net—"Dhadangil" is operated in Lanjanmadgu and 60–70 lbs. in scare rope fishing during April. Below Etturunagaram as far as Bhadrachellum, fishing is sporadic, depending upon the periodic visits of fishermen from Rajahmundry. But, up to 600 lbs. of fish are captured per day by them. At Dummugudem and Bhadrachellum only 30–40 lbs. of fish were estimated daily during summer. At Rajahmundry some 300 lbs. of fish were being captured daily in March, some batches of fishermen operating nets two or three times every 24 hours. In addition, 200–300 lbs. of fish are also captured close to Dhawaleswaram weir along its 5 miles width. Species of fish consisted mostly of *Puntius kolus* and *Labeo fimbriatus* with several *Labeo* spp., *Cirrhina reba*, *Thynnichthys sandkhol*, *Silonia childrenii*, *Pangasius pangasius Proeutropiichthys taakree* with some minor forms. 25–30% of the total mainly of various prawns.

Hilsa ilisha migrates upwards during monsoon forming the most important single commercial fishery item in the Godavary. Its further progress beyond Bhadrachellum is retarded by the weir and hence great concentrations occur below both Dhawaleswaram and Bhadrachellum weirs during partial floods. Similarly, *Pangasius* from the lower estuary is caught in numbers when it also attempts to migrate upwards during floods.

In the Krishna at Vijaywada, 200–300 lbs. of fish are captured daily, almost the same species as in Rajahmundry being available ; *Thynnichthys* and prawns however are not so abundant. *Hilsa* and *Pangasius* are obtainable here also during monsoon months. Elsewhere, large fish landings are mainly sporadic with either the onset of monsoon when brood fish are caught or during visits of deep water fishermen.

Fishing Centres, Markets and Fishermen :

Some fish is caught along the entire estimated total length of 4,000 miles of river courses in the two systems. Except for the forested regions between Manthani and Etturunagaram and the Papikonda gorges of the Godavary for 200 miles, and 170 miles of the Krishna below Moravakonda, fishing pressure is intense as considerable local demand for fish is to be met. But as each town or a village also possesses one or two tanks, tank fishing is preferred as it is an easier and reliable source of fish supply than the river itself. Some surplus fish from the "madgus", dam and weir sites, may be exported to near by towns on occasions. Fish are captured regularly below all the dams and weirs and irrigational headworks by manipulating the water flow through the sluices and attracting fish from lower pools to the aprons. Stranded fishes while ascending during surplus discharges are also removed regularly. Several tons of fish are captured for a few days in the beginning of the rains from all such locations. Overflow channels of tanks and small reservoirs are also similarly fished. If connecting the main rivers below, such overflows attract spawning fishes resulting in bumper catches for a day or two. Several older reservoirs and tanks (*e.g.* Sulekere and Vanivilas-sagar in Mysore) have developed very favourable ecological conditions over the course of years yielding profitable standing crops of fish.

Considering all factors, commercial fishing is restricted to a streteh of 25 miles above Dhawaleswaram weir on the main Godavary and for 18–20 miles above the Krishna barrage at Vijaywada all round the year. The shallow, almost lacustrine impoundments offer considerable scope for active freshwater fishing during the major part of the year and for *Hilsa*, *Pangasius*, etc., during monsoon as stated earlier.

Fishermen communities (as a distinct caste) are found in almost every village or town. Except in the lower reaches and near deep summer shelters, weir sites or around reservoirs, where fishing is more lucrative, they engage in fishing activities only seasonally. Their number varies from place to place according to the potentialities. There were 400 around Nizamsagar, an equal number close to Lanjanmadgu (but only 30–40 able to fish in the pool), 90 close to Mancherial (Ramagundem), and less than 25 each at Soun, Dummugudem and Bhadrachellum. About 120 fishermen visit the "madgu" at the confluence of the Manjira with the Godavary from Nagpur. and 150 fishermen annually move upwards in the Godavary from the coastal districts carrying with them boats and nets as far as Etturunagaram for a distance of 185 miles fishing the entire length. At Rajahmundry—Dhawaleswaram, 250 resident fishermen are active all round the year.

In the Krishna system, fishermen are found mainly along the Thunga-bhadra. 365 fishermen were estimated in a length of 67 miles above Sunkesula, 90 below (up to Kurnool) and 150 up to the confluence. At Vijaywada itself there were about 150 resident fishermen.

Fishermen directly sell their catches in the markets except at Rajahmundry and Vijaywada where retailers buy then ; catches are also auctioned by fishermen cooperative bodies as middlemen exploitors are rare. No cold storage facilities are available for preservation as only freshly caught fish or 'live' fish (from Collair Lake) is preferred by the consumers in these cities. Hyderahad—Secunderabad cities derive their fish supply largely from tanks or coastal areas.

An itinerant tribe of fishermen known as "Killekethas" move up and down the Thunga-bhadra, including its tributaries and reservoir areas in batches of 30–40 men. They visit all the deep pools inaccessible to local fishermen employing efficient fishing techniques. Their catches are sold or bartered in the adjoining towns and villages.

Game fishing by anglers using rod and line or throw lines is common in all rapids and pools. Streams in the Western-ghats, the Indravati in Eastern-ghats and rocky sections of the middle reaches, are fished by local fishermen by crude rod and line as well as sport minded anglers as large Mahseers are available in them.

Craft and Gear :

Boats.—As in the two systems, the rivers remain shallow for 8–9 months, but flow torrentially during the 3–5 months in a year, fishing boats are rarely encountered, except in the lower reaches which are also navigable for some distance. Plank built canoes act as ferries for short distances all along the middle reaches even in small tributaries. Flat-bottomed fishing boats are first noted near Etturunagaram having been introduced by fishermen from Rajahmundry. In the Bhadrachellum stretch, 47 fishing boats were licensed. About 160–170 boats meant for fishing are concentrated at Rajahmundry and 75–80 boats operate through the Papikonda gorges as far as Palavaram above. In the Krishna there are no fishing

boats except 25–30 near Vijaywada as no boats can ply beyond 10–12 miles above owing to rapids.

Coracles (rounded large bamboo frame baskets covered with buffalo hides) are noted in some parts of the Thunga-bhadra and are commonly employed for cast net fishing or angling. The deep pool fishermen—the "Killekethas", use dried water gourds as floats for treading water upright while fishing. These methods are remarkably adaptable to quiet pools as well as large reservoirs where boats are not readily available. Rafts formed by logs of wood or bamboo are employed in fishing operations in Lanjanmadgu and probably are found elsewhere in both rivers.

Nets.—Fishing contrivances of Hyderabad State (now merged to form parts of several States) are described by Mahmood and Rahimullah (1947) but refer mainly to tank fishing by nets, traps, nooses and other miscellaneous methods. Cast nets of various meshes, with or without radial cords or pockets, are the commonly used type employed by individual fishermen. The nets are designed for small or large fishes with meshes and sinkers adjusted to suit individual local requirements including capture of prawns. At Vijaywada, rice grains are sprinkled over likely spots, and prawns which are thus attracted are captured 2–3 hours later in numbers by casting these nets. At Etturunagaram, the local fishermen employ six or more nets which held together and drawn in a concerted manner as a single drag net within shallow streams, can efficiently capture considerable numbers of fish. At Manthani, scare ropes strung with leafy-branches are tied to a single cast net which is provided with an improvised float and sinkers, and drawn as a bottom drag net, it can land profitable numbers of even large fish from the silty bottom.

Simply designed rectangular drag nets are used on the Thunga-bhadra and sandy stretches of the Godavary. A large type of drag net, "Dhadangil", peculiar to the Godavary within the Lanjanmadgu, is made of 50'×25' rectangular pieces of nets with one inch mesh at the bottom, increasing gradually 5 to 6 inches at the top. Five to fifteen individual pieces are tied together during mass fishing operations and dragged from the middle of the pool to the bank as a seine. A raft is used to take the net to the middle of the river. Gill nets also known as "Eduvala" (2½' wide and with a mesh of ½" only) are extensively employed for smaller fish during September and October.

Fishermen at Rajahmundry have evolved efficient nets adopted to seasonal flow conditions, species and sizes of fish. The range of drag nets called variously "Thurusuvala", "Rekhavala", "Juruguvala", "Garmivala", "Janapavala", "Thokavala", etc., are employed according to requirements as far Etturunagaram by seasonally migrant fishermen. Large round sinkers roll along the bottom when small fishes and prawns are dragged ashore in "Juruguvala". As denoted, each differs in its functional operation.

Rocky pools and rapids remain largely untouched by drag nets, but light entangling gill nets are used in such situations. Effective wall nets (entangling type) which sink to the bottom adjusting to the contour, are used by "Killekethas" along the Thunga-bhadra. These nets are generally made of hemp.

Small drag nets made of mosquito netting cloth, shaped into triangular push nets slung on bamboo frame work, are also used for fish and prawns during all the months along the shallow margins.

Stake nets are seldom employed in deep water areas, but prawns are captured in the middle reaches of the Godavary by semi-permanent stake nets.

"Rangoon" nets—drifting gill nets of 25' height, are used for capturing ascending *Hilsa* close to Rajahmundry and Vijaywada ; they have proved useful in Nizamsagar reservoir for large species of fish.

Traps.—Trapping in the main rivers is only a seasonal activity since most traps can be fixed only in conjunction with temperory barriers erected for the purpose in shallow waters of upto 5' depth. At Ramagundem—Mancherial area, every two-three miles of the sandy stretch for 35–40 miles is barricaded by closely knit fibrous shoots of a water resistant plant, and split bamboo box traps are placed with entrances alternately opening towards and against the current so that both upstream and downstream moving fish may be trapped. The entire construction is know as "Eduthorakhalu" in Telugu. Once the barriers are erected and traps are in place, during November–December, it requires efforts of only 2–3 fishermen to maintain and periodically empty the traps, through the dry months until June. Elsewhere traps were not observed but rocky channels are similarly reported to be utilised in the Krishna system in the Thunga-bhadra. These are called "Thadakes" or "Kodems", and ensure a regular supply of fish to nearby towns. Spillway channels from reservoirs and tanks are similarly utilised for trap fishing or brood fish ; connections with rivers, paddy fields, irrigational canals or their distributarie, are extensively fished by traps—the young fish soon after monsoon months bseing mainly captured.

Line Fishing.—Long lining is not popular in both river systems except in the short deltaic stretch. But throw lines consisting of 3–4 baited hooks and weighted with heavy sinkers are in evidence near deeper pools. Throw line fishing is the most exclusive type within the Papikonda gorges as net fishing is not po sible. Angling by hook and line is common, often semi-commercially as anglers are not all professional fishermen. Catfishes, Carps, Mahseers, Eels, Spiny eels or Murrels are caught by line fishing.

Micellaneous Methods.—Poisoning of pools of the minor tributory streams within forest tracts is prevalent. Several plants, shrubs and trees whose poisonous values are well known, are freely used by villagers in Etturunagaram—Rajah. mundry stretch and Thunga-bhadra and other head-waters where forests abound. "Gara kaya"—*Acacia pennata* (fruits and stem), "Gangu kaya— *Pongamia pinnata* (Seeds and roots), "Chillaka duddhi" or "Chilla kaya—*Caesaria tomentosa*, "Chirukatige"—*Derris scandens* (barks), "Multi"—*Caesalpinia nuga* (fruits and stem), "Kanigi"—*Barringtonia asiatica* (barks, roots and seeds), "Ippepundi" or the "Mowrah" meal and oil cakes left after extraction of oil from the fruits of *Madhuca longifolia* and some others are used for killing fish or narcotise them for easy capture. Milky juices of several *Euphorbia* plants and of the plants of Asclepidaceae family, are also reported as effective piscicidal agents. Dynamiting pools where large sized fish shelter, is also practised, when gelignite is procurable. In some Western-ghat tanks, fish are also shot, but harpooning is not known.

Spawning Grounds and Seed Resources :

Sufficient numbers of fish "seed"—larval young, fry or fingerlings of *Catla catla, Labeo fimbriatus, L. calbasu* and *L. bata* amenable to culture, though available, attempts have not been made to collect them during the limited favourable hydrological conditions of the monsoon months in sufficient numbers. Fingerlings of *Catla* are obtained from paddy fields fed by the Dhawaleswaram canal in the deltaic region of the Godavary during August–September months. Fry and fingerlings of *Labeo rohita* and *Cirrhina mrigala* are being imported from Calcutta or Cuttack for planting tanks or reservoirs and their fingerlings have been transplanted directly into the lower Godavary and Krishna by governmental agencies ; they

have now acclimatised and bred as indicated by the juveniles and adults commonly fished in the two river stretches below. Their fingerlings also occur in paddy fields and a good proportion of fish landed from the Collair lake, consists of these two species, as taey obviously enter the lake during monsoon along with *Catla catla*, *L. fimbriatus*, *L. bata*, *Cirrhina reba* and *Puntius sarana* as fry or larvae.

Larval stages of most of the above species, *Thynnichthys sandkhol* and some Catfishes, have occurred during monsoon flows at Rajahmundry and Vijaywada. But the quantities are never large, and are profusely mixed with uneconomical forms.

C. catla and *L. fimbriatus* are known to spawn at a few places. The surplus channel of the Yaglaspur tank near Manthani, a mile upstream from Lanjanmadgu, has yielded spawning *L. fimbriatus*, fertilised eggs, fry and fingerlings in large numbers during or after local floods. *Catla* fry and fingerlings are collected here as well as in inundated low banks at Etturunagaram. Elsewhere, sporadic occurrence of batches of various brood carps, eggs, larvae, fry or fingerlings are recorded. Necessarily these sites are situated close to summer shelters and gorges and influenced by floods and rains (David, 1959). It may not be profitable to explore for fish "seed" in upper waters and shallow middle reaches where brood stocks are limited in number.

Reservoirs like Lakkanavaram and Kamareddy tanks, stocked earlier with *Catla*, *L. rohita* and *L. fimbriatus* have become self sufficient. Young of the stocked species are obtained in some years indicating that the species had spawned. Such reservoirs may prove valuable "bundh" type of tanks where riverine conditions are simulated during rains including the fish to spawn. There are no records of spawning of stocked carps in Maharashtra and Mysore States.

Spawning grounds and larval "seed" locations may be explored more advantageously 10–15 miles above Rajahmundry, around Konavaram (Fig. 1) and vicinities where required species are found in fairly large numbers. Streams and tributaries which attract brood stocks from the main rivers (*e.g.* the Sabari, Moneru) require exploration.

Scope for Fish Culture :

Fish cultural practices in watersheds are handicapped as quick growing *L. rohita* and *C. mrigala* are not endemic to the rivers. Possibilities of culturing *Puntius pulchellus*, *P. kolus* and other forms, have not been tried seriously. *L. potail*, *L. porcellus*, *Tor khudree*, *T. mussallah* or *T. neilli* are perhaps suited for culture (David, 1953) but no attempts appear to have been made to collect their young.

In the interior districts of Andhra Pradesh, consumers largely prefer the predaceous Murrels (*Channa* spp.), Catfishes like *Clarias*, *Heteropneustes*, *Wallago*, *Ompok* and *Mystus* to Carps. Majority of irrigational tanks are valued mainly for Murrels and Catfishes as fry and fingerlings of the former are removed from tank to tank for stocking. But cultural practices designed to rear carnivorous species in confined ponds are not understood. In weed infested tanks where abundant forage fish population (genera like *Amblypharyngodon*, *Rasbora*, *Oxygaster*, *Puntius*) offer appreciable fishery yield, *Channa*, and some Catfishes grow well. Little scientific observations have been made to rationalise culture of such species. Recently the author (*Mss.*) has observed that the Catfish, *Pangasius pangasius* can be cultivated in tanks without proving hazardous to other fish as it is not predaceous and thrives on a diet of molluscs, insects and plant matter. Its fry and fingerlings are available at Rajahmundry and Vijaywada if its stocking is ultimately undertaken.

Palaemon molcolmsonii and *P. carcinus* which attain over 6" in length are known to thrive already in fields irrigated by canals connecting the Godavary. Young stages that are apparently brought during monsoon are trapped. Little attention has so far been given to stock them for culture as is done in West Bengal.

Remarks ;

The watersheds of each system offer fishing opportunities depending upon the geographical regions they drain and volume of water which is greatly fluctuating. Headwater and middle reach pools offer better scope for fish production where each species presents its own attraction and creats its own problem to the fishermen and to fishery biologist. Distribution patterns of fish populations vary considerably from the upper to the lowest reach. Fish concentrations are found in rocky or silty pools, brush wood or under cut banks, all of which offer concealment. But more fish are found in the 'mudgus' or below dams, weirs, and canal head works. Stable conditions established during dry months are affected by freshets during rains and torrential flows when major runs of fish take place but such fish are compelled to scatter very widely in the river systems. Overfishing is prevalent in most areas and scope for improved conservation measures exist. Large range migrant is only the *Hilsa ilisha* in the lower deltaic regions, and such protection given by stricter measures of prohibition and rescue, probably should meet the major needs of all other species.

Value of prohibition on capture of juveniles of *Labeo rohita* and *Cirrhina mrigala* after introducing them into the Godavary and the Krishna, has yielded beneficial results now recognised by most fishermen. Such experience may find wider applications. Licensing of nets or boats by the government has already facilitated statistical returns and has ensured cooperation of the trade near Rajahmundry.

Trapping all existing fish in certain stretches by erection of barriers, may have to be controlled. It is not clear if such barriers help to reduce the marketable fishes of the rivers as a whole ; in a way these barriers offer an opportunity to study fish populations as migrating fishes can be counted and analysed for dynamics of fish populations as in some countries. Considerable lengths appear still under-exploited within the gorges, deep rocky pools and rapids.

While checking easy fish movements, the dams and weirs have proved cumulatively virtual traps causing fish losses. Irrigational diversions have perhaps caused shoaling, destroying many natural shelters ; but, construction of high dams ensure a better flow throughout the dry season. It is reported that large prawns have failed to form an item of the fishery yield in the Manjira above the Nizamsagar dam after its construction. Similarly, *Catla* also has declined.

Even very little care in stocking and maintaining irrigation canals, has increased fish catches of some Bihar canals. Usefulness of canals for fish culture has been overlooked in India so far, and lack of knowledge and proper species of fish in such locations, have so far checked development of irrigation canals in the two water sheds for fish culture.

A Systematic List of the Fishes of the Godavary and the Krishna River Systems

(Classification is according to Berg)

*These fish were recorded by the author in the present collection

Species of Fish	Recorded in the Godavary	Krishna	Remarks
1	2*a*	2*b*	3
Order CLUPEIFORMES			
Sub-Order CLUPEOIDEI			
Super family CLUPEOIDAE			
Family *Clupeidae*			
Sub-family Clupeini			
**Gadusia chapra* (Hamilton)	×	×	Observed in lower reaches.
**Hilsa Ilisha* (Hamilton)	×	×	Forms a commercial fishery in the lower reaches as far as Bhadrachellum
Family *Engraulidae*			
**Setipinna phasa* (Hamilton)	×	×	In lower reaches.
Sub-Order NOTOPTEROIDEI			
Family *Notopteridae*			
**Notopterous notopterus* (Pallas)	×	×	
Notopterus osmanii Das and Rahimullah	..	×	Recorded by Rahimullah (1943*a* and 1944) from reservoirs around Hyderabad.
Order CYPRINIFORMES			
Sub-Order CYPRINOIDEI			
Family *Cyprinidae*			
Sub-family Abramidinae			
**Chela atpar* (Hamilton)= *Laubuca atpar* (Hamilton) =*Chela cachius* (Bleeker)	×	×	
**Chela laubuca* (Hamilton) = *Laubuca laubuca* (Hamilton)	×	×	
Oxygaster argentea (Day)	..	×	Recorded by Chacko and Kuriyan (1948) and David (1957)
Oxygaster bacaila (Bloch)	×	..	Recorded by Rahimullah (1943*a*).
Oxygaster boopis (Day)	..	×	Recorded by Fraser (1942).
**Oxygaster clupeoides* (Hamliton)	×	×	
**Oxygaster phulo* (Hamilton)	×	×	

Species of Fish	Recorded in the Godavary Krishna		Remarks
1	2*a*	2*b*	3
Sub-family Rasborinae			
Barilius bakeri (Day)	×	..	Recorded by Rahimullah (1944).
**Barilius barila* (Hamilton)	×	×	
**Barilius barna* (Hamilton)	×	×	
**Barilius bendelisis* (Hamilton)	×	×	
Barilius canarensis (Jerdon)	..	×	Recorded by Bhimachar and Rau (1941), Chacko and Kuriyan (1948) and David (1957) in the Thunga-bhadra sub-drainage.
**Barilius evezardi* (Day)	..	×	A rediscovery since Day's (1889) description.
Barilius gatensis (Cuvier and Valenciennes)	..	×	Recorded in the Thunga-bhadra sub-drainage by Bhimachar (1942), Chacko and Kuriyan (1948) and David (1957).
Danio (*Brachydanio*) *rerio* (Hamilton)	×	×	Recorded by Mahmood and Rahimullah (1947*a*) and David (1957).
**Danio* (*Danio*) *aequipinnatus* McClelland = *D. strigillifer* and *D. malabaricus* (Jerdon).	×	×	
Danio fraseri (Hora)	×	..	Recorded by Hora and Misra (1938).
**Esomus barbatus* (Jerdon)	×	×	
**Esomus danricus* (Hamilton)	×	..	Recorded by Raihmullah (1943*a*) and Mahmood and Rahimullah (1947).
**Rasbora daniconius* (Hamilton)	×	×	
Rasbora labiosa (Mukerji)	×	..	Recorded by Hora and Misra (1938).
**Rasbora rasbora* (Hamilton) = *R. buchanani* (Day)	×	×	
Sub-family Cyprininae			
Amblypharyngodon melittinus (Cuvier and Valenciennes)	..	×	Recorded by David (1957).
**Amblypharyngodon mola* (Hamilton)	×	×	
**Aspidoparia morar* (Hamilton)	×	×	

Species of Fish	Recorded in the Godavary	Krishna	Remarks
1	2*a*	2*b*	3
**Catla catla* (Hamilton)	×	×	Seen in lower reaches and deep pools of the middle range.
Cirrhina fulungee (Sykes)	..	×	Recorded by Hora and Misra (1942), Fraser (1942), Chacko and Kuriyan (1948) and David (1957).
**Cirrhina mrigala* (Hamilton)	×	×	Lower reaches were planted with this species which is now acclimatised.
**Cirrhina reba* (Hamilton)	×	×	
**Crossochilus latius* (Hamilton)	×	×	Recorded in the Krishna headwaters by Fraser (1942) and Hora and Misra (1942).
Garra bicornuta (Rao)	..	×	Recorded by Hora (1937).
Garra jerdoni (Day)	..	×	Recorded by Chacko and Kuriayan (1948) and David (1957).
**Garra lamta* (Hamilton)	×	..	New Record (refer text).
**Garra mullya* (Sykes)	×	×	
**Garra stenorhynchus* (Jerdon)	×	×	
Labeo ariza (Hamilton)	..	×	Recorded by David (1957).
**Labeo bata* (Hamilton)	×	..	-
**Labeo boga* (Hamilton)	×	×	Resembles *L. kawrus* (Sykes) and *L. ariza* (Hamilton).
**Labeo boggut* (Sykes)	×	×	
**Labeo calbasu* (Hamilton)	×	×	
**Labeo dussumeiri* (Cuvier and Valenciennes)	..	×	Recorded in the Thungabhadra by David (1957).
**Labeo fimbriatus* (Bloch)	×	×	
**Labeo gonius* (Hamilton)	×	×	Generally in lower reaches.
**Labeo kawrus* (Sykes)	..	×	Recorded by Day (1889) and David (1957).
**Labeo pangusia* (Hamilton)	×	?	First record in the Godavary; reported in the Thungabhadra (refer text).
**Labeo porcellus* (Haeckel)	×	×	
**Labeo potail* (Sykes)	×	×	
**Labeo rohita* (Hamilton)	×	×	Available in lower reaches where it was transplanted.

Species of Fish	Recorded in the Godavary	Krishna	Remarks
1	2*a*	2*b*	3
**Oreichthys cosuatus* (Hamilton)	×	×	Also recorded by David (1957).
**Osteobrama belangerii* (Cuvier and Valenciennes) = *Rohtee belangerii* (Cuvier and Valenciennes)	×	×	
**Osteobrama cotio* var. *peninsularis* Silas = *Rohtee cotio* var. *cunma* = *R. alfrediana* = *R. duvaucelli* (Cuvier and Valenciennes	×	×	Recorded in the Eastern-ghat streams by Misra (1938) as *R. duvaucelli* (Cuvier and Valenciennes).
Osteobrama neilli (Day) = *Rohtee neilli* (Day)	×	×	Recorded by Rahimullah (1944 in the Godavary and Fraser (1942), Hora and Misra (1942) and David (1957) in the Krishna.
**Osteobrama vigorsii* (Sykes) = *Rohtee vigorsii* Sykes = *R. dayi* Hora and Misra ?	×	×	(refer text for variations).
**Osteochilus* (*Osteochilichthys*) nashii (Day) = *Scaphiodon nashii* (Day)	..	×	
**Osteochilus* (*Osteochilichthys*) *thomasii* (Day) = *Scaphiodon thomasii* (Day)			
Parapsilorhynchus prateri Hora and Misra	×	..	Recorded by Hora and Misra (1938).
Parapsilorhynchus tentaculatus (Annandale)	×	×	Recorded by Annandale (1921) and by Hora (1938) in the Indravathi sub-drainage of the Godavary.
**Puntius amphibius* (Cuvier and Valenciennes)	×	×	
**Puntius chola* (Hamilton)	×	×	
Puntius conchonius (Hamilton)	×	..	Recorded by Mahmood and Rahimullah (1947*a*).
Puntius curmuca (Hamilton)	..	×	Recorded by David (1957).
Puntius dorsalis (Jerdon) = *Barbus puckelli* (Day)	..	×	Recorded by David (1957).
Puntius filamentosus (Cuvier and Valenciennes) = *P. mahecola* (Cuvier and Valenciennes)	..	×	Recorded by Misra (1938) in Nallamalai hill streams and by David (1957) in the Bhadra.
Puntius fraseri (Hora and Misra)	×	..	Recorded by Hora and Misra (1938).

Species of Fish	Recorded in the Godavary	Krishna	Remarks
1	2*a*	2*b*	3
**Puntius gelius* (Hamilton)	×	..	New record (refer text).
**Puntius guganio* (Hamilton) = *Barbus ambassis* (Day)	×	..	
**Puntius pulchellus* (Day) = *Barbus dobsonii* (Day) = *B. Jerdoni* (Day)	×	×	Refer also Hora and Misra (1942.)
**Puntius kolus* (Sykes)	×	×	
Puntius lithopidos (Day)	..	×	Recorded by David (1957).
Puntius melanampyx (Day)	..	×	Recorded by Misra (1938) in Nallamalai hill streams.
Puntius malanostigma (Day)	×	..	Recorded by Hora and Misra (1938).
Puntius narayani (Hora)	..	×	Recorded by Hora (1937) and David (1957).
Puntius parrah (Day)	×	×	Recorded by Hora and Misra (1938).
**Puntius sarana* (Hamilton) = *Barbus chrysopoma* (Cuvier and Valenciennes = *B. pinnauratus* (Day)	×	×	
Puntius terio (Hamilton)	×	×	Recorded by Rahimullah (1943).
**Puntius ticto puntius* (Hamilton) = *P. stoliczkanus* (Day)	×	×	*P. stoliczkanus* recorded by Rahimullah (1944) in the Godavary ; also refer Silas (1952).
**Rohtee* (*Rohtee*) *ogilibii* Sykes = *Mystacoleucus ogilibii* (Sykes)	×	×	
**Schizmatorhychus* (*Nukta*) *nukta* (Sykes) = *Labeo nukta* (Sykes)			
**Tor khudree* (Sykes)	×	×	
**Tor mussullah* (Sykes)	×	×	
**Tor* (?) *neilli* (Day) = *Barbus neilli* (Day)	..	×	Recorded by Day (1878), Rahimullah (1943*a*) and David (1957).
**Thynnichthys sandkhol* (Sykes)	×	×	
Family *Cobitidae*			
Botia striata (Rao)	..	×	Recorded by Hora (1937) and David (1957).
**Lepidocephalus guntea* (Hamilton)	×	×	
**Lepidocephalus thermalis* (Cuvier and Valenciennes)	×	×	

Species of Fish	Recorded in the Godavary Krishna		Remarks
1	2*a*	2*b*	3
Nemachilichthys ruppelli (Sykes)	..	×	Recorded by Fraser (1942) and Hora and Misra (1942).
Nemachilichthys shimogensis (Rao)	..	×	Recorded by Hora (1937) and David (1957).
Nemachilus anguilla (Annandale)	×	×	Recorded by Annandale (1921) and Rahimullah (1944) in the headwaters of the Krishna and the Manjira (Godavary) respectively.
Nemachilus bhimachari (Hora)	..	×	Recorded by Hora (1937) and David (1957).
**Nemachilus botia* (Hamilton) var. *aureus* (Day)	×	×	
**Nemachilus dayi* (Hora)	×	×	
**Nemachilus denisonii* (Day)	×	×	
**Nemachilus evezardi* (Day)	×	×	
**Nemachilus sinuatus* (Day)	..	×	
**Nemachilus striatus* (Day)	..	×	
Sub-order SILUROIDEI			
Super family SILUROIDAE			
Family *Siluridae*			
**Ompok bimaculatus* (Bloch) = *Callichrous macropthalmus* (Blyth) = *C. pabda* (Hamilton) = *C. malabaricus* (Cuvier and Valenciennes)	×	×	*C. macropthalmus* recorded by Chacko and Kuriyan (1948), *C. pabda* and *C. malabaricus* by Rahimullah (1943*a* and 1944) and Fraser (1942).
Ompok pabo (Hamilton)	×	×	Recorded by Hora and Misra (1942); occurs in Thungabhadra.
**Wallago attu* (Bloch and Schneider)	×	×	
Family *Bagridae*			
**Mystus aor* (Hamilton)	×	×	
Mystus armatus (Day)	×	×	Recorded by Rahimullah (1944).
Mystus bleekeri (Day)	×	×	Recorded by Rahimullah (1943*a*) and Chacko and Kuriyan (1948).
**Mystus cavasius* (Hamilton)	×	×	

Species of Fish	Recorded in the Godavary Krishna		Remarks
1	2*a*	2*b*	3
**Mystus gulio* (Hamilton)	×	×	Recorded by Hora and Misra (1942) and Fraser (1942) from the headwaters of the Krishna.
Mystus malabaricus (Jerdon)	×	. .	Recorded by Mahmood and Rahimullah (1947*a*).
**Mystus seenghala* (Sykes)	×	×	
Mystus tengara (Hamilton)	×	×	Recorded by Rahimullah (1943*a* and 1944).
**Mystus vittatus* (Bloch)	×	×	
**Rita hastata* (Valenciennes)	×	×	
**Rita pavimentata* (Valenciennes)	×	×	
Family *Sisoridae*			
**Bagarius bagarius* (Hamilton)	×	×	
**Gagata itchkeea* (Sykes)	×	×	
Gagata viridescens (Hamilton)	×	×	Recorded by Hora and Misra (1938) in the Godavary, Rahimullah (1943*a*) and David (1957) in the Krishna drainages.
Glyptothorax annadalei (Hora)	×	. .	Recorded by Hora and Misra (1938).
Glyptothorax conirastrae var. *poonensis* (Hora)	. .	×	Recorded by Hora and Misra (1942) and Fraser (1942).
Glyptothorax lonah (Sykes) = *G. dekkanensis* (Gunther)	. .	×	Recorded by Hora and Misra (1942), Fraser (1942) and Chacko and Kuriyan (1948).
Glyptothorax trewavasae (Hora)	. .	×	Recorded by Hora (1938).
Family *Schilbeidae*			
**Eutropiichthys goongwaree* (Sykes)	×	×	
Neotropius khavalchor (Kulkarni)	. .	×	Recorded by Kulkarni (1951).
**Proeutropiichthys taakree* (Sykes)	×	×	
**Pseudeutropius atherinoides* (Bloch)	×	×	
**Silonia childrenii* (Sykes)= *Silundia sykesii* (Day)	×	×	This form is usually confused with *S. silondia* (Hamilton) which is distributed in the Ganga river system as well as some other rivers including the Cauvery which record is doubtful.

Species of Fish	Recorded in the Godavary Krishna		Remarks
1	2*a*	2*b*	3
Family *Pangasidae*			
**Pangasius pangasius* sub-species *godavarii* nov.	×	×	(Refer text ; family *Pangasidae* is merged in *Schilbeidae*).
Family *Heteropneustidae*			
**Heteropneustes fossilis* (Bloch)	×	×	
Family *Clariidae*			
**Clarias batrachus* (Linneaus)	×	×	
Clarias dussumeiri dussumeiri Valenciennes	..	×	Recorded by Hora (1941) from Belgaum (Krishna-drainage).
Order ANGUILLIFORMES			
Sub-order ANGUILLOIDEI			
Family *Anguillidae*			
**Anguilla bengalensis* Gray	×	×	
Anguilla anguilla (Hamilton)	×	..	Recorded by Hora and Misra (1938) : synonymous with *A. bengalensis*.
Order BELONIFORMES			
Sub-order SCOMBERSOCOIDEI			
Family *Belonidae*			
**Xenentodon cancila* (Hamilton)	×	×	
Order CYPRINODONTIFORMES			
Sub-order CYPRINDONTOIDEI			
Family *Cyprinodontidae*			
**Oryzias melanostigma* (McClelland)	×	×	
**Panchax lineatus* (Valenciennes)	×	×	
Order MUGILIFORMES			
Sub-order MUGILOIDEI			
Family *Mugilidae*			
**Mugil parsia* (Hamilton)	..	×	
Order OPHICEPHALIFORMES			
Family *Ophicephalidae* (=*Channidae*)			
**Channa gachua* (Hamilton)			
**Channa leucopunctatus* (Sykes)	×	×	Recorded by Hora and Misra (1938) and Fraser (1942).

Species of Fish	Recorded in the Godavary	Krishna	Remarks
1	2*a*	2*b*	3
**Channa marulius* (Hamilton)	×	×	
**Channa striatus* (Bloch)	×	×	
**Channa punctatus* (Bloch)	×	×	
Order PERCIFORMES			
Sub-order PERCOIDEI			
Family *Centropomidae*			
Ambassis baculis (Hamilton)	×	..	Recorded by Hora and Misra (1938).
**Ambassis nama* (Hamilton)	×	×	
**Ambassis ranga* (Hamilton)	×	×	
Family *Leiognathidae*			
Leiognathus equulus (Forskal)	..	×	
Family *Sciaenidae*			
**Johnnius dussumieri* (Cuvier and Valenciennes)	×	..	This species may be the same as *Pseudosciaena coitor* (Hamilton).
**Pama pama* (Hamilton)	×	..	
Family *Nandidae*			
Nandus nandus (Hamilton)	×	..	Recorded by Mahmood and Rahimullah (1947*a*).
Sub-order ANABONTOIDEI			
Family *Anabantidae*			
**Anabas testudiens* (Bloch)	×	×	Both forms recorded in the Collair lake.
**Colisa fasciatus* (Bloch) and Schneider)			
Family *Polycanthidae*			
Macropodus cupanus (Cuvier and Valenciennes)	×	×	Recorded by Hora (1937) in the Bhadra.
Sub-order GOBIODEI			
Family *Gobiidae*			
**Awous stamineus* (Valenciennes)	×	×	New record in the Godavary.
**Glossogobius giuris* (Hamilton)	×	×	
Order MASTCEMBELIFORMES			
Family *Mastacembelidae*			
**Macrognathus aculeatus* (Bloch)	×	×	
**Mastaeembelus armatus* Lacépède	×	×	
**Mastacembelus pancalus* (Hamlton)	×	×	

Summary :

During a survey of the middle and lower reaches of the Godavary and the Krishna rivers, the status of the fishing industry, resources, fishermen, fishing methods, etc., have been assessed. Only the lower reaches close to the delta sustain a freshwater commercial fishing industry. How best the tanks, and reservoirs within the watersheds can be developed, is discussed in the light of availability of fish or prawn "Seed" for stocking.

Fish species identified in author's collections and all earlier records number 157 in both drainages and are briefly discussed from a commercial, sport or culturable value. 47 species are considered valuable of which 20 are major species.

A number of new records are recognised and discussed in the light of their systematic variations or zoo-geographical affinities. *Pangasius pangasius* of the two rivers is considered a new variety on account of its differences from the holotype.

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STUDIES ON FISH AND FISHERIES OF THE GODAVARY AND THE KRISHNA RIVER SYSTEMS—PART II*

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SYSTEMATIC AND ZOO-GEORAPHICAL NOTES ON FISH SPECIES

In the first part of this paper, problems mainly concerning the fisheries of the two major river systems have been dealt with by the author. While identifying the collection of fish, certain interesting facts comprising new or rare records to the drainages emerged, and some variations from the originally described types were noticed. The author has included a few such observations in this part. No separate list of references is given in this part as the relevant references are already listed in Part I.

Barilius evezardi Day

Barilius evezardi, Day, *Fish. India.* pp. 593–594, 1878.

After Day (*loc. cit.*) recorded the above species near Poona in the headwaters of the Krishna, the occurrence of this form from the drainage is not mentioned by any later observers. A single specimen, 56 mm. in total length was obtained from Vijaywada on the Krishna, and agrees with Day's description, except that there are a minute pair of maxillary barbels. The species resembles *Barilius barila*, but without any colour spots. A dark band is however noticeable on the caudal fin from its base to the forkal ends as in *B. evezardi*. Eyes are comparatively much larger than in *B. barila*.

Crossocheilus latius (Hamilton)

Cirrhina latia, Day, *Fish. India.* pp. 548, 1878.

Crossocheilus latius, Hora and Misra, *J. Bombay Nat. Hist. Soc.* **40** : 31–32, 1938.

Although distribution of this species was actually noted by Hora and Misra (*loc. cit.*) and Fraser, (*op. cit.*) within the Krishna headwaters, these records appear to have been overlooked by subsequent students of fish zoo-geography, who thus limited its distribution only as far south as Deolali hills in the headwaters of the Godavary. Though author has not now recorded it from the Krishna, possibilities of its occurrence in the middle course of the river cannot be precluded, because in the Godavary, large numbers have been obtained from isolated spots near Manthani, Etturunagaram, Dummugudem and Rajahmundry. Author has found that larval stages of this species are available within the Ganga river

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30 miles below Hardwar during monsoon floods in considerable numbers. The species forms an important item of small fish population near and above Kanpur during December and January months, obviously having grown from the drifting young earlier. In the Deccan rivers too, the young similarly seem to distribute widely in the middle reaches.

Garra lamta (Hamilton)

Garra lamta, Hora, *Rec. Ind. Mus.*, **22** : pp. 660–662, 1921.

While redescribing known species of the genera *Garra* Hamilton, Hora (*loc. cit*) restricted this species to eastern part of the Vindhya range and Nepal Terai. A single specimen, 96 mm. from Etturunagaram on the Godavary agrees with the description of a female specimen of the species given by Hora, hence extending its range southwards of the Satpura trend of mountains.

Labeo pangusia (Hamilton)

Labeo pangusia, Day, *Fish. India.* 541, 1878.

Labeo pangusia, Shaw and Shebbeare. *J. Asi. Soc. Bengal*, **III** : 56–57, 1937.

Labeo pangusia (Hamilton) and *L. dyocheilus* (McCelland) resemble each other so closely in appearance and characters, that they may even be synonymous with each other. Five specimens ranging in sizes from 138 to 293 mm. collected below Dummugudem weir and Rajahmundry in the Godavary, are distinctly referable to either of the two species and posses the undermentioned fin and scale formula.

D. 3/10–11, P. 16–7, V. 9, A. 2/5, L. l. 40–41, L. tr. 7/6–9.

There are five rows of scales between the lateral line and base of ventral fin. A pair of small maxillary marbels are concealed within the lateral labial folds on the snout, and in larger specimens, a very minute rostral pair is also present. The lower jaw is interrupted in the middle. Though Day (*loc. cit.*) mentions that lips are not fimbriated in both species, in the Godavary specimens the lower lips show slight fimbriations. Fins are slightly edged with black, and a dark blotch is present above the region of the pectoral fin-base laterally on the body, behind the opercular opening.

Day (*loc. cit.*) mentions distribution of *L. pangusia* as "Himalayan range and generally through Sind, the Deccan, N. W. Provinces to Bengal, Cachar and Assam", and that of *L. dyocheilus* as "Sind hills and along the Himalayas to Sikkim and Assam. It is common in Assam". In the absence of any specific mention of the river or locality in the Deccan where it is actually found, present record of either of these two species is perhaps the first in the Godavary. Recently David (1953) extended the distribution of *L. dyocheilus* to the Mahanadi river system. Godavary specimens show certain variations from *L. dyocheilus*, the characters agreeing closely with *L. pangusia* rather than with the former as described.

Fry and fingerling sized *L. dyocheilus* and *L. pangusia* are difficult to be distinguished and separated from *L. rohita* in lots. The species in the Godavary might thus inadvertently has been planted into the river by the State's Fisheries Departments while stocking the lower reaches with the latter form from Northern rivers, and has readily found congenial surroundings within the swift rapids and gorges being a sub-montane form. Until the species is actually obtained in the headwater streams of the Godavary system, this conjecture for its occurrence below Dummugudem weir seems more pausible, than that of a natural distribution*

*Dr. Y. R. Tripathi of the Thunga-bhadra Lacustrine Unit has recently recognised *L. pangusia* in the Thunga-bhadra river (personal communication).

Specimens of *L. pangusia* by appearance resemble somewhat *L. porcellus* in the shape of the head, snout and possession of lateral labial folds, but differ in having a distinctly interrupted lower lip as against the continuous lip in *L. porecellus*.

Osteobrama vigorsii (Sykes)

Rohtee vigorsii, Day, *Fauna Brit. Ind. Fishes* **1** : 341, 1889.

Rohtee vigorsii, Hora and Misra, *Rec. Ind. Mus.* **42** : 100–101, 1940.

Rohtee vigorsii, Chauhan and Ramakrishna, *Rec. Ind. Mus.* **51** : 408, 1953.

Silas (1952) replaced the generic name *Rohtee* Sykes by *Osteobrama* Heckel to include all but one Indian species *e.g. R. ogilibii* Sykes. Hence *R. vigorsii* Sykes is redesignated as *Osteobrama vigorsii* (Sykes). Author collected eight specimens from the Godavary and Krishna rivers, fin formulae, scale counts etc. of which are described below :

Total (mm.) length	Dorsal rays	Pectoral rays	Ventral rays	Anal rays	L. l. scales
95	3/8	17	10	3/26	72–73
96	3/8	16	10	3/27	73–75
*105	3/8	16	10	3/24	68–70
139	3/8	15	10	3/20	73–74
*142	3/8	16	10	3/19	68–69
*150	3/8	16	10	3/20	65–67
161	3/8	16	10	2/21	73–74
182	3/8	16	10	3/21	71–72

*These resemble *R. dayi* Hora and Misra in possessing fewer number of anal rays.

The species is distinguishable in the field by the characteristic concavity extending from the snout to the nape and extension of the cleft of the mouth to well below the anterior margin of the orbit. There are two minute maxillary barbels in smaller individuals.

Day's description is as follows :

D. 11 (3/8), P. 19, V. 10, A. 25–28 (2–3/23–26), L. l. 75–80.

From the above descriptions, it now seems that the species is very highly variable in the number of anal rays and lateral scales. None of the author's specimens have shown 19 rays on the pectoral fin. Till more material is examined the species may be said to conform to the following description :

D. 3/8, P. 16–19, V. 10, A. 2–3/19–28, L. l. 65–80.

In smaller individuals, the lower jaw is not longer than the upper and actually is shorter. Probably, protruberance of the maxillary bones occurs with an increase in the size of the fish or that these may constitute altogether a separate variety. Author is inclined to believe that *R. dayi* Hora and Misra (Hora and Misra, 1940) from the same drainage is probably a variety or a sub-species of *R. vigorsii* on account of the intermingling characters and highly variable numbers of anal rays and lateral line scales.

Puntius gelius (Hamilton)

Barbus gelius, Day, *Fish. India*. 577–578, 1878.

Puntius gelius is recorded by Day (*loc. cit.*) as occurring in "Ganjam, Orissa, Bengal and Assam". A single specimen, 34 mm. in total length obtained from Ecturunagaram on the Godavary, corresponds to Day's description. This is another record of extension of a species from the Ganga-Brahmaputra southwards to the Deccan. Its occurrence in Mahanadi is already recorded by David (1953).

Pangasius pangasius Godavarii, sub-species Nov.

Pangasius buchanani, Day, *Fish. India*. 470, 1878.

Pangasius pangasius, Hora, *J. Bombay Nat. Hist. Soc.* **40** : 355–366, 1939.

Pangasius pangasius (Hamilton) is widely distributed from Malay Archipelago to India, and has been recorded in the Ganga-Brahmaputra, Mahanadi, Godavary, Krishna and the Cauvery river systems mainly in their lower reaches and tidal fresh and brackish waters within their deltae. As such, its distribution is discontinuous from one river system to the other, and stocks in the Godavary and the Krishna rivers are completely isolated from those of the Ganga river system, and are hence bound to exhibit some heterogenity. Juveniles obtainable in commercial quantities at Rajahmundry and Vijaywada, possess comparatively larger eyes than the Gangetic form. In the following table, measurements of ten random specimens, exhibiting significant differences in the diameter of eyes, length of snout, interorbital width, length of dorsal and pectoral spines etc., are given from each river system for comparison.

Table showing the comparative body measurements in *Pangasius pangasius* (Hamilton)
(In millimetres)

Charcters	Gangetic Forms										Godavary Forms									
Total length . .	193	178	168	166	152	145	140	137	135	135	168	157	157	156	155	154	153	136	127	113
Furcal length	160	146	140	140	126	125	119	116	114	114	144	134	127	134	130	130	125	115	111	95
Length of head	35	32	30	28	27	26	25	25	25	25	31	29	27	28	29	28	29	26	24	21
Diameter of eye	5	5	4·5	4·5	4	4	4	4	3·5	3·5	6	6	6·5	6	6	6	6	5·5	3·5	3·5
Length of snout	15·5	14	12	13	12·5	12	10·5	11	11	11	11	12	9	10	10	10·5	11	10	9	8·5
Inter-orbital width . .	21	20	19	18	18	18	15	16	16·5	17	16	15	15	17	16	16	16	15	13	12
Length of dorsal spine . .	26	24	24	21	22	23	20	22	18	19	20	18	18	19	. .	20	17	18	15	14
Length of pectoral spine . .	25	26	25	23	23	23	23	23	22	22	22	19	18	21	. .	20	20	20	18	16

From the above measurements the following differences in the proportions of eye and spines are now evident. Other conspicuous dissimilarities are also mentioned.

Diameter of eye is nearly 1½ times larger in the Godavary specimens than in the Gangetic forms. Similarly, snout length and interorbital distances are relatively shorter, Dorsal and pectoral spines are not only shorter but are markedly weak and thin compared with Gangetic specimens. In other body proportions, length of barbels and number of fin rays, no major differences are noticeable. Eye diameter given by Hora (*loc. cit.*) in the table accompanying his description of the species appears to be rather too large (6–9 mm.) in specimens ranging between

93–150 mm.) and such large eyes are not encountered in the Gangetic specimens as found by the author in several hundreds of specimens examined for a study of its biology. However, Hora (*loc. cit.*) mentions also a large eyed form from the Bhavani river within the Cauvery system. Probably all Deccan forms of *Pangasius* have relatively larger eyes, consequent upon these rivers having clear water flows during a major part of the year unlike in the more turbid Ganga-Brahmaputra rivers.

	Gangetic Specimens	Godavary-Krishna Specimens
Diameter of eye in length of head	6·3–7·4	4·2–5·2
Length of snout in length of head	2·2–2·4	2·4–3 0
Interorbital distance in length of head	1·5–1·7	1·7–1·8
Length of dorsal spine in furcal length	5·3–6·7	6·4–7·4
Length of pectoral spine in furcal length	5·2–6·4	5·8–7·1
Dorsal spine has 14–16 serrations posteriorily		Dorsal spine has 11–14 serrations
Pectoral spine is rugose in front		Pectoral spine is smooth, or only slightly rough.

Gangetic forms show four distinct regions where palatine teeth are sharp and grouped together in a discontinuous semi-circle as figured by Hora (*loc. cit.*) in text figure 1 *a* on p. 357. The Godavary forms of equivalent sizes show minute teeth fused to form a continuous semi-circle.

In view of the above differences, the Godavary specimens are now considered to belong to a new subspecies. A separate statistical account describing the degree of divergence exhibited by the Godavary samples as distinct from those of the Ganga, is being contributed by the author elsewhere.

Occurrence of both *Oxygaster clupeioides* and *O. bacaila* in the two river systems is further to be confirmed as both resemble each other and are distinguished by slight differences in the number of anal rays and scales. Author's specimens are more closely referable to *O. clupeioides*. *Labeo ariza* and *L. kawrus* have been originally described from the Cauvery and the Krishna drainages respectively, and resemble each other and perhaps are synonyms. *L. porcellus* and *L. potail* were thought to be synonymous with each other by Hora and Misra (1942) but author's present collection indicates that they are distinct. *L. porcellus* possesses more rays on the dorsal fin, has a narrower, more cylindrical body and two pair of well developed barbels, as against fewer rays on the dorsal fin, a deeper body and one pair of small maxillary and a very minute pair of rostral pair of barbels in *L. potail*. Both pair of barbels, or only the rostral pair may sometimes be absent in *L. potail* leading to confusion in their correct identity.

In the Thunga-bhadra headwaters as far down as Kurnool and in the Krishna, specimens identical with *Barbus neilli* described by Day (1878) are available and conform to the features of the genus *Tor* (which comprises all species of the "true" Mahseers known in Indian waters), such as four well developed barbels, large

scales and thick continuous lips of which the *lower is provided with an uninterrupted posterior fold with a median lobe.* The last simple dorsal ray is osseous and very strong and spinous in *Tor* genus. But in *B. neilli* all the characters of mouth or lips resemble a *Tor*, the dorsal ray alone though osseous, being very weak. This form therefore is to be accommodated in the genus, as it cannot be a *Puntius* as discussed by Smith (1945). Perhaps this form could be a local variety of *Tor mussallah* or *T. khudree*, both of which also occur in the Thunga-bhadra. *Ompok pabo* is the only other species of genera *Ompok* occurring in India besides *O. bimaculatus* and has been described from North East India in Assam. Significance of its occurrence in Peninsular India has been probably overlooked by earlier workers.

In the recent years considerable evidence has been adduced on the zoogeographical affinities of various genera of fish found in Peninsular India to support the 'Satpura Hypothesis' advanced by Dr. Hora to account for the striking similarity in fish fauna with the Malay Archipelago with those of the far removed Peninsular India. It is held that the evolutionary divergences shown by a number of such forms are explainable to the geological and climatic changes affecting the migrant forms from the Far East during the course of their distribution in four or five waves. These became isolated along the Vindhya-Satpura mountains across India from Assam, through the Garo-Rajamahal hills in the east, the Deolali hills in the Western-ghats and downwards to Travancore hills, and evolved into the rich variety of forms noticed now, which have affinities with the Malayan fish fauna. In the Godavary and the Krishna these isolates are represented amongst others by a number of genera, sub-genera, species, sub-species and races. Resemblances and divergence exhibited by forms belonging to the genera, *Osteochilus Schismatorhynchus, Rohtee, Puntius, Tor, Osteobrama, Labeo, Crossocheilus, Garra, Thynnichthys, Silonia, Pangasius, Eutropiichthys, Neotropius, Gagata, Glyptothorax,* and *Clarias* have been already discussed by Silas (1952). The extent of endemicity of fish fauna within the river systems has also been discussed in detail by Hora in his various contributions and by a few others.

Strictly speaking, even within the two river systems and their tributaries there appears to be some amount of isolation. *Danio fraseri, Rasbora labiosa, Parasilorhynchus prateri, Puntius fraseri* and *Glyptothorax annadalei* have been so far recognised only in the upper waters of the Godavary. Similary, the following species have not been recorded outside the Krishna water-shed, or rivers to the north of it.

Notopterus osmanii Das and Rahimullah
Barilius evezardi (Day)
**Barilius canarensis* (Jerdon)
**Barilius gatensis* (Cuvier and Valenciennes)
Cirrhina fulungee (Sykes)
**Garra bicornuta* (Rao)
Carra jerdoni (Day)
**Labeo ariza* (Hamilton)
**Labeo dussumeiri* (Cuvier and Valenciennes)
**Labeo kawrus* (Sykes)
Osteochilus nashii (Day)
Osteochilus thomasii (Day)
**Puntius curmuca* (Hamilton)
**Puntius dorsalis* (Jerdon)
Puntius filamentosus (Cuvier and Valenciennes)
**Puntius lithopidos* (Day)
Puntius melanampyx (Day)
**Puntius narayani* (Hora)
**Tor* (?) *neilli* (Day)
**Botia striata* (Rao)
Nemachilichtys ruppelli (Sykes)
**Nemachilichthys shimogensis* (Rao)
**Nemachilus bhimachari* (Hora)
**Nemachilus sinuatus* (Day)
**Nemachilus striatus* (Day)
Glyptothorax trewavasae (Hora)
Neotropius khavalchor (Kulkarni)

*These species are recorded from the Thunga-bhadra sub-drainage.

It is not however correct to assume that the above species may not occur in the Godavary water-shed or elsewhere, because, *Parasilorhynchus tentaculatus* which was earlier recorded by Annandale (1921) in the Krishna head-waters has later been recongnised in the Indravathy river, a tributary of the Godavary in the Eastern-ghats by Hora (1938). *Puntius melanampyx* a form originally recorded from Travancore hills and Western-ghat streams has occurred in the Nallamalai hills of the Eastern-ghat ranges. Similarly, *Barilius bakeri*, and *Puntius melanostigma* from Travancore hills is recorded by Rahimullah (1944) and Hora and Misra (1938) from the Krishna and the Godavary systems respectively. A number of forms now-recorded are found in a fairly extensive area of the Western-ghat hills in streams draining both east and west *Esomus barbatus* and *Lepidocephalus thermalis*, both Peninsular forms, have been recognised in the lower reaches of the Godavary. Fish fauna of both northern and southern India intermingle to a certain extent in the two water-sheds.

Catla catla, Puntius amphibius, P. gelius, P. guganio, Mystus gulio, Johnnius dussumeiri, Awous stamineus, and a number of tidal forms, are found both in the lower reaches of the Godavary (as well as the Krishna) and the Mahanadi (David, 1953). The eastern narrow, but flat coastal strip is annually subjected to extensive flooding, the inundations during monsoon months interconnecting the two river systems with each other. Hence a likelihood of young stages of some fresh-water species to be washed from one drainage into the other, cannot entirely be disregarded. For some forms at least the way of Southward migration may not be entirely through the 'Satpura' trend of hills. Distribution of marine or estuarine forms can however be easily explained.

ON TWO NEW STRIGEID PARASITES FROM INDIAN BIRDS (TREMATODA : STRIGEIDAE)

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During the course of a study of trematode parasites of birds from four districts of Uttar Pradesh in India *viz.*, Bulandshahar, Hardoi, Varanasi and Lucknow, the writers collected several strigeid parasites. One of these forms has been found to be a new species of the strigeid genus *Ophiosoma* Szidat, 1928, and one of *Cotylurus* Szidat, 1928. Descriptions of these two new strigeid species forms the subject matter of the present paper.

Ophiosoma bubulci sp. nov.

Four specimens of this strigeid were collected from the small intestine of two out of two dozen specimens of Cattle Egret, *Bubulcus ibis coromandus* (Linnaeus), examined by the authors at various places in the four districts mentioned above.

Description.—The body (Fig. 1) is long and distinctly bisegmented. The forebody is small, appears cup-like with a narrow anterior opening and a prominent constriction at its middle. It measures 0·721–0·790 mm. in length and 0·760–0·912 mm. in maximum breadth. The hindbody is narrow and cylindrical with a truncated end, and measures 2·340–2·468 mm. in length and 0·507–0·593 mm. in maximum breadth in the middle region.

The suckers are feebly developed. The oral sucker is small and subterminal, measuring 0·043–0·044 mm. in diameter. The ventral sucker is situated in the middle of the forebody. It is much larger than the oral sucker and measures 0·081–0·100 mm. in diameter. The holdfast organ is a large bilobed structure rarely projecting from the anterior opening of the forebody. It bears a pair of additional lobe-like structures. The adhesive gland is situated medially behind the holdfast organ and also extends anteriorly between the lobes of the holdfast organ.

The mouth leads directly into a delicate pharynx, measuring 0·029–0·033 mm. by 0·033 mm., there being no prepharynx. The oesophagus and the intestinal caeca are present, but as they are masked by the vitelline follicles and other organs, they could not be observed in whole mounts. They are, however, visible in sections.

The gonads are situated in the posterior half of the hindbody. The testes are multilobed structures. The anterior testis measures 0·402–0·410 mm. by 0·405–0·416 mm. The posterior testis is smaller than the anterior one and measures 0·270–0·283 mm. by 0·351 mm. The vas deferens runs back and is continued

into a coiled seminal vesicle situated just behind the posterior testis. The ductus ejaculatorius is short and joins the uterus near the base of the genital cone to form the ductus hermaphroditicus.

The ovary is situated in the middle region of the hindbody just in fornt of the testes. It is large and sub-spherical, and measures 0·240 mm. by 0·194–0·201 mm. The vitellaria are extensively developed and consist of small follicles, most of which are crowded in the anterior half of the hindbody. In the posterior half of the hindbody, the vitelline follicles are restricted to a narrow median and ventral band, which extends almost upto the level of the seminal vesicle, but never enters into the zone of the copulatory bursa. In the forebody, the vitelline follicles are scant and are limited to two small masses within the lobes of the holdfast organ. The vitelline reservoir and the Mehlis' gland are intertesticular. The uterus extends anteriorly, as evident from the distribution of the eggs, beyond the ovary for a considerable distance, then runs back, and eventually joins the male duct at the base of the genital cone to form the ductus hemaphroditicus. It contains a few (five to eight) eggs, which are light yellow, oval, and measure 0·0872–0·1052 mm. by 0·0542–0·0611 mm. The copulatory bursa is large with well developed muscular wall and contains a small genital cone. It opens to the exterior by a terminal opening.

Discussion.—Of all the species of the genus *Ophiosoma* Szidat, 1928, hitherto known, the present form closely resembles *O. crassicolle* Dubois and Rausch, 1948, from which it can he easily distinguished by its considerably smaller body, and by the relative size of the body segments. The body of the present form is 3·061–3·258 mm. long, whereas in *O. crassicolle* it is 7·400–8·100 mm. long (5·800 mm. long in young immature specimens), The hindbody in the present form is about three and a half times longer than the forebody, whereas in *O. crassicolle*, it is about six times longer. Furthermore, the ventral sucker of the present form is twice as large as the oral sucker, whereas in *O. crassicolle* the suckers are almost equal in size.

The present form, therefore, represents a new species of the genus *Ophiosoma* Szidat, 1928, for which *Ophiosoma bubulci* sp. nov. is proposed.

A key to the species of the genus *Ophiosoma* Szidat, 1928.

1. Forebody longer than broad. Testes entire.....2.
   Forebody broader than long. Testes lobed.....3.
2. Hindbody about three times longer than forebody..... ....*O. macrocephalum* Verma, 1936
   Hindbody about seven times longer than forebody.... ....*O. microcephalum* Szidat, 1928
3. Body never exceeding 3·5 mm. in length. Posterior testis smaller than anteri or one .....*O. bubulci* sp. nov.
   Body always more than 5·5 mm. in length. Posterior testis not smaller than anterior one..... ....4.
4. Maximum length of body upto 17 mm. Testes small... . ...*O. patagiatum* (Creplin, 1846) Dubois, 1937.
   Maximum length of body never exceeding 8·5 mm. Testes large..... ....*O. crassicolle* Dubois and Rausch, 1948.

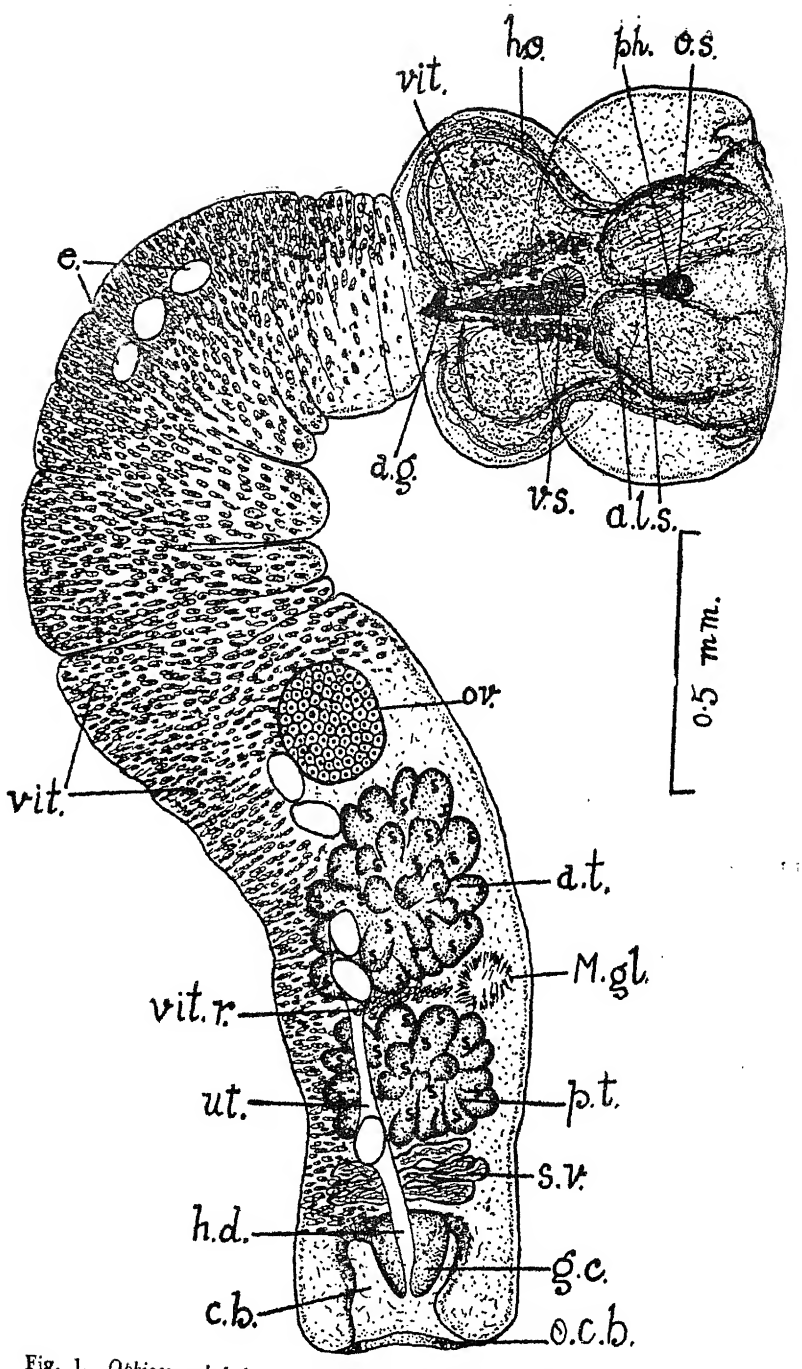

Fig. 1. *Ophiosoma bubulci* sp. nov. ; type specimen from ventral view (hindbody twisted and seen in lateral view).

LETTERING

a.g.—adhesive gland ; a.l.s.—additional lobe-like projections of holdfast argen ; a t.—anterior testis ; c b.-copulatory bursa ; d.h.o.—dorsal lobe of holdfast organ ; e.—eggs ; e.d—ejaculatory duct ; g.b.—genital bulb ; g c,—genital cone ; g.p.—genital pore ; h.d.—hermaphroditic duct ; h o.—hol ifast organ ; i.c.—intestinal caecum ; M.gl.—Mehlis gland ; o c.b.—opening of copulatory bursa ; oes,—oesophagus ; o.s.—oral sucker ; ov.—ovary ; ph.—pharynx ; p ps —lobe like projections of pseudosu.kers ; ps.—pseudosucker ; p.t —posterior testis ; s.v.—seminal vesicle ; ut.—uterus ; v.h.o.—ventral lobe of holdfast organ ; vi.—vitelline follicles ; vit.r.—vitelline reservoir ; v.s.—ventral sucker.

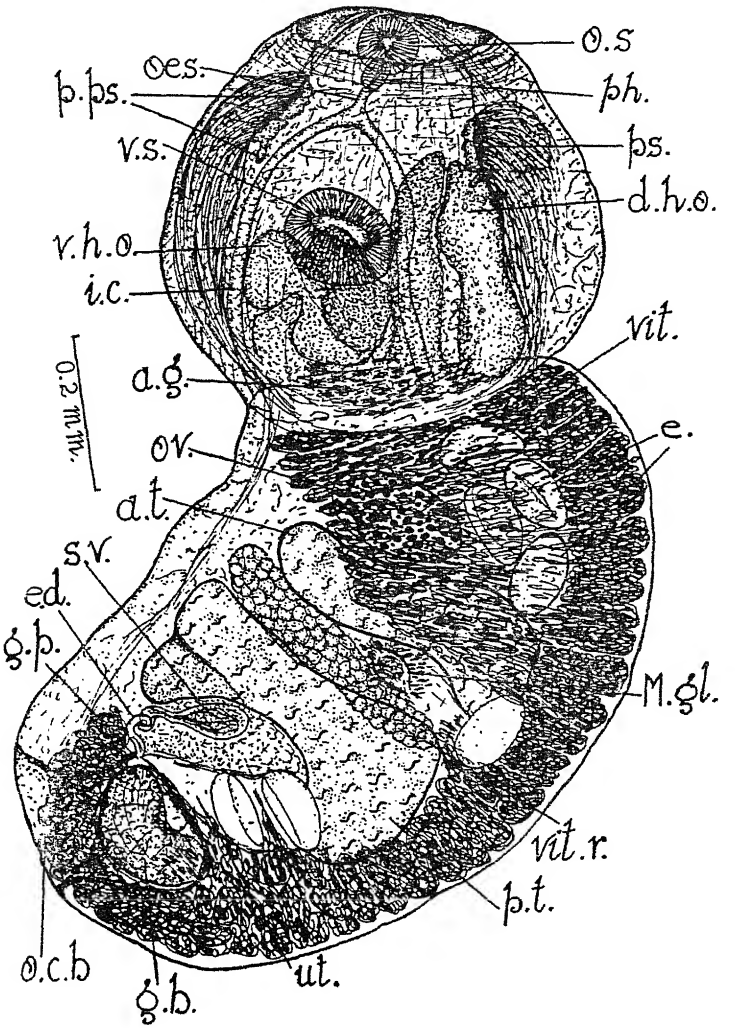

Fig 2. *Colylurus intermedius* sp. nov. ; type specimen from ventral view (hindbody twisted and seen in lateral view).

Cotylurus intermedius sp. nov.

About two dozen specimens of this strigeid were obtained from the intestine of one out of two Pheasant-tailed Jacana, *Hydrophasianus chirurgus* (Scopoli) shot in the Chinhat Lake, about six miles from Lucknow.

Description.—The body (Fig. 2) is small, compact, and distinctly bisegmented ; the segments slightly overlapping each other. The forebody is globular with a narrow anterior opening, and measures 0·538–0·644 mm. in length and 0·570–0·659 mm. in maximum breadth in its middle region. The hindbody is sac-like with a broad rounded posterior end. It is about twice the length of the forebody, and measures 0·937–1·232 mm. in length and 0·584–0·700 mm. in breadth in the middle.

The suckers are well developed. The oral sucker appears subterminal and measures 0·079–0·091 mm. by 0·085–0·119 mm. The ventral sucker, situated near the middle of the forebody, measures 0·100–0·136 mm. by 0·142–0·150 mm. Pseudosuckers are present in the form of groove-like depressions on the inner side of the dorsal wall of the forebody, and each is provided with one or more small lobe-like projections. These small projections of the pseudosuckers are characteristic of the present form (Figs. 2, 3). The holdfast organ is comparatively small and consists of the usual dorsal and ventral lobes (Fig. 1), each of which is a bilobed structure. The dorsal lobe of the holdfast organ does not extend beyond the ventral sucker, whereas the ventral lobe usually does. A large diffused adhesive gland is present immediately behind the holdfast organ.

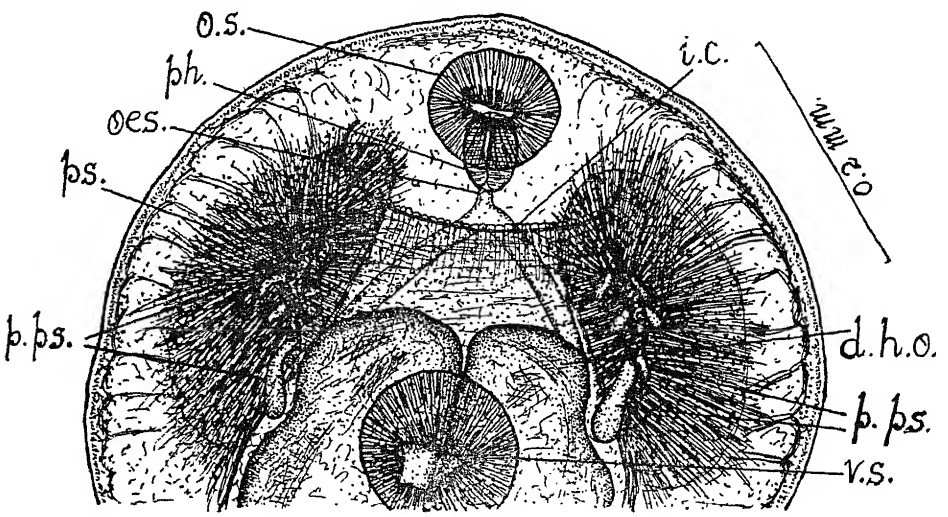

Fig 3. *Cotylurus intermedius* sp. nov. ; anterior half of forebody of paratype magnified to show structure of pseudosuckers (ventral view).

The mouth leads directly into the pharynx, there being no prepharynx. The pharynx is moderately muscular, and measures 0·048–0·061 mm. by 0·036–0·042 mm. A short oesophagus is present. The intestinal caeca are narrow and extend back upto the posterior end of the body, but they are greatly obscured by the vitellaria and other organs.

The gonads are located in the middle of the hindbody. The testes are transversely elongated structures ; the posterior testis is larger than the anterior one

and often with a concave hind border. The anterior testis measures 0·130–0·191 mm. by 0·380–0·465 mm., whereas the posterior one measures 0·190–0·276 mm. by 0·340–0·469 mm. The vas deferens is obscured by the vitelline follicles and other organs. A small pear-shaped seminal vesicle is present just behind the posterior testis. A narrow ductus ejaculatorius leads from the seminal vesicle and opens along with the uterus into the copulatory bursa.

The ovary is transversely oval, just pre-testicular in position, and measures 0·095–0·120 mm. by 0·178–0·188 mm. The vitellaria consist of large follicles distributed throughout the entire length of the hindbody. The follicles are dense in the pre-testicular region of the hindbody, but posteriorly, they run in the form of a thick band along the midventral line upto the hind end, where they pass around the wall of the bursa and again merge dorsally. A large vitelline reservoir is present in the inter-testicular region close to the ootype complex. The uterus is short containing a few (five to nine) eggs which are oval, operculate, yellowish, and measure 0·1000–0·1148 mm. by 0·0495–0·0726 mm. The copulatory bursa contains a large muscular bulb-like structure, the so-called "genital bulb" of Szidat (1928), which is bent towards the dorsal side. The bursa opens to the exterior through a terminal opening.

Discussion.—Of all the species of the genus *Cotylurus* Szidat, 1928, hitherto known, the present form shows greatest resemblance to *C. lintoni* (Vigueras, 1944) Dubois and Vigueras, 1949, from which it can be distinguished by its posterior testis being larger than the anterior one, by its pseudosuckers being provided with small lobe-like projections, and by the distribution of its vitelline follicles. Moreover, the eggs of the present form are considerably larger than those of *C. lintoni*.

Evidently, the present form represents a new species of the genus *Cotylurus*, and the name *Cotylurus intermedius* is proposed for it.

A consideration of the valid species of the genus Cotylurus Szidat, 1921.

The genus *Cotylurus* was created by Szidat (1928) with *Cotylurus cornutus* (Rudolphi, 1808) as the genotype, which was originally described by Rudolphi (1808) under the name of *Amphistoma cornutum*. Szidat (1928) characterised the genus *Cotylurus* by the presence of prominent bulb-like structure in the copulatory bursa. He called this structure as the "genital bulb". Subsequently, Vigueras (1944) established a new genus *Choanodiplostomum* with *Choanodiplostomum lintoni* as the genotype. This genus was based on a single specimen obtained from the intestine of *Gallinula chloropus cerceris* Bango. Vigueras (1944) did not specify the chief distinguishing characters of his new genus, but it appears that he based it mainly on the presence of a robust genital cone in the copulatory bursa. Later on, Dubois and Vigueras (1949), on a re-examination of the type material of *Choanodiplostomum lintoni*, concluded that the structure described earlier by Vigueras (1944) as the genital cone was actually the genital bulb, and hence they synonymised the genus *Choanodiplostomum* with *Cotylurus*.

Besides the genotype *C. cornutus* (Rud.), Szidat (1928) included four additional species under *Cotylurus* viz., *Amphistoma erraticus* Rudolphi, 1809, *Amphistoma platycephalus* Creplin, 1825, *Amphistoma variegatus* Creplin, 1825, and *Strigea aquavis* Guberlet, 1922. Subsequently, several species have been added to the genus by various workers. Van Haitsma (1931) traced the development of *Cercaria flabelliformis* Faust, 1917, and La Rue (1932) of *Cercaria communis* Hughes, 1928, and they included the adults of these cercariae under *Cotylurus* as *Cotylurus flabelliformis* and *Cotylurus communis* respectively. Ishii (1932) described the species *C. japonicus*, and

Dubois (1934) described *C. hebraicus* and *C. syrius*. Subsequently, in the year 1937, Dubois transferred *Amphistoma pileatus* Rudolphi, 1802 to the genus *Cotylurus*. Vidyarthi (1937) described *C. orientalis* from India.

In 1938, Dubois, in his "Monograph on Strigeida", regarded *C. variegatus* (Creplin, 1825) Szidat, 1928 as a synonym of *C. pileatus* (Rudolphi, 1802) Dubois, 1937, but he considered the remaining twelve species valid. Subsequent to the publication of the Monograph by Dubois, four species have been described under the genus *Cotylurus* viz., *C. ban* by Yamaguti (1939), *C. strictus* by Endrigkeit (1940), and *C. brevis* and *C. medius* by Dubois and Rausch (1950).

Later in the year 1953. Dubois, in his "Systematics of Strigeida", dropped *C. aquavis* (Guberlet, 1922) Szidat, 1928 as a synonym of *C. erraticus* (Rudolphi, 1809) Szidat, 1928. Further, he regarded *C. communis* (Hughes, 1928) La Rue, 1932 as a variety of *C. platycephalus* (Creplin, 1825) Szidat, 1928. Thus he considered fourteen species of the genus valid. One species *viz., C. strictus* Endrigkeit, 1940, however, escaped his attention.

Yamaguti (1958), in his "Systema Helminthum", retained *C. aquavis* and *C. communis* as valid species in the list given by him. He included *C. strictus*, but unfortunately *C. lintoni* (Vigueras, 1944) Dubois and Vigueras, 1949 is missing from his list. Thus he placed sixteen valid species under *Cotylurus*.

The present writers are in full agreement with Dubois (1953) in considering *C. aquavis* as a synonym of *C. erraticus* and *C. communis* as a variety of *C. platycephalus* Thus in the opinion of the present writers, the genus *Cotylurus* Szidat, 1928. includes the following sixteen species, including the one described by them in the preceding pages :

1. *Cotylurus cornutus* (Rudolphi, 1808) Szidat, 1928.
2. *C. erraticus* (Rudolphi, 1809) Szidat, 1928.
3. *C. platycephalus* (Creplin, 1825) Szidat, 1928.
4. *C. flabelliformis* (Faust, 1917) Van Haitsma 1931.
5. *C. japonicus* Ishii, 1932.
6. *C. hebraicus* Dubois, 1934.
7. *C. syrius* Dubois, 1934.
8. *C. gallinulae* (Lutz, 1928) Dubois, 1937.
9. *C. pileatus* (Rudolphi, 1802) Dubois, 1937.
10. *C. orientalis* Vidyarthi, 1937.
11. *C. ban* Yamaguti, 1939.
12. *C. strictus* Endrigkeit, 1940.
13. *C. lintoni* (Vigueras, 1944) Dubois and Vigueras, 1949.
14. *C. bravis* Dubois and Rausch, 1950.
15. *C. medius* Dubois and Rausch, 1950.
16. *C. intermedius* sp. nov.

A key to the species of the genus *Cotylurus* Szidat, 1923.*

1. Vitelline follicles do not enter into the forebody..... 2.
   Vitelline follicles enter into the basal part of the forebody..... 14.

* The species *C. strictus* Endrigkeit, 1940 could not be included in this key as original reference was not available to the authors.

2. Body large (more than 4·0 mm. in length). Oral sucker ventral in position. .... *C. platycephalus* (Creplin, 1825) Szidat, 1928.

Body never more than 4·0 mm. in length. Oral sucker terminal or subterminal..... .... 3.

3. Eggs as large as ovary..... ...*C. japonicus* Ishii, 1932.

Eggs smaller than ovary. .... 4.

4. Receptaculum seminis present .....*C. orientalis* Vidyarthi, 1937.
Receptaculum seminis absent .... 5.

5. Testes multilobed..... ..... 6.

Testes not multilobed..... .... 7.

6. Oral sucker terminal. Eggs 90μ by 58μ *C. pileatus* (Rudolphi, 1802) Dudois, 1937.

Oral sucker subterminal. Eggs 105μ by 63μ .....
.....*C. medius* Dubois and Rausch, 1950.

7. Testes reniform or slightly bilobed..... ..... 8.

Testes trilobed..... 11.

8. Body 3·0 mm. long..... ....*C. gallinulae** (Lutz, 1928) Dubois,1937.

Body never more than 2·0 mm. long..... ..... 9.

9. Genital bulb with a muscular thickening on its dorsal side... .....
.....*C. ban* Yamaguti, 1939.

Genital bulb without a muscular thickening. ..... . 10.

10. Pseudosuckers with small lobe-like projections. *C. intermedius* sp. nov.

Pseudosuckers without projections....*C. lintoni* (Vigueras, 1944) Dubois and Vigueras, 1949.

11. Hindbody more than two and a half times longer than forebody.....
.....*C. cornutus* (Rudolphi, 1808) Szidat, 1928.

Hindbody never more than two and a half times longer than forebody.
....12.

12. Eggs 120-137μ by 68--80μ.....*C. syrius* Dubois, 1934.
Eggs 91-110μ by 50–70μ ..... 13.

13. Body 0·56–0·85 mm. long. Suckers almost equal.....
.....*C. flabelliformis* (Faust. 1917) Van Haitsma, 1931.

Boby 1·0–2·0 mm. long. Ventral sucker larger than oral sucker.....
..... *C. brevis* Dubois and Rausch, 1950.

14. Forebody broader than long. Testes trilobed, situated in posterior half of hindbody..... .....*C. erraticus* (Rudolphi, 1809) Szidat, 1928.

Forebody longer than broad. Testes bilobed, situated in middle region of hindbody.....*C. hebraicus* Dubois, 1934.

*The description of this species is inadequate.

Summary :

Descriptions of two new strigeid parasites, one under the genus *Ophiosoma* Szidat, 1928 (Subsubfamily Strigeini Dubois, 1936), and the other under the genus *Cotylurus* Szidat, 1928 (Subsubfamily Cotylurini Dubois, 1936) form the subject matter of the present paper.

Ophiosoma bubulci sp. nov. is described from four specimens collected from the small intestine of two Cattle Egrets, *Bubicus ibis coromandus* (linnaeus). This species is closely related to *O. crassicolle* Dubois and Rausch, 1948, from which it is distinguished by the size of body, by relative size of two body segments, and by the ratio of the two suckers.

Cotylurus intermedius sp. nov. is described from about two dozen specimens collected from the intestine of a Pheasant-tailed Jacana, *Hydrophasianus chirurgus* (Scopoli). This species closely related to *C. lintoni* (Vigueras, 1944) Dubois and Vigueras, 1949, from which it differs in relative size of testes, in the presence of small lobe-like projections of pseudosuckers, in distribution of vitelline follicles, and in larger size of its eggs. A consideration of valid species of *Cotylurus* Szidat, 1928 with a key to them is also given.

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MORPHOLOGICAL STUDIES AND TAXONOMIC DISCUSSION OF A NEW TREMATODE *PSEUDOARTYFECHINSOTOMUM LARUEIFORMIS* n.g. n.sp. (TREMATODA : ECHINOSTOMATIDAE)

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[Recieved on 20th April, 1961]

Introduction :

While surveying reptilian fauna of Jabalpur region two very interesting worms were discovered from the deoenum of *Varanus*. The worm here is being named *Pseudoartyfechinostomum larueiformis*, n.g., n.sp. More than 25 specimens of the new form were found out, and they were found to be belonging to the subfamily *Paryphostominae* Mendheim. 1943, of the family *Echinostomatidae* The present host is a new reptilian host. In this paper a revised definition of the subfamily *Paryphostominae*, 3 comparative tables belonging to the 3 genera and a key to the 3 genera have been given. This, along with a short discussion of the subfamily may make a brief and useful review, and try to remove some controversies which have been existing in connection with this important group of echinostomes.

The studies of live material have always been giving the best information, *inter alia*, permanent preparations have also been studied. Stains like Ehrlich's haematoxylin, haemalum, cosin, carmalum and acid alum carmine have been used to advantage for studying the complete morphology of the parasites, including the spinations. Fixation was done in aqueous Bouin's fluid.

All measurements have been given in millimeters, unless otherwise stated.

Description : (Fig. 1, 2, 3, 4, 5)

Pseudoartyfechinostomum larueiformis n.g. n.sp. : Body flat, narrow and elongate, tapering at both the ends, measuring $5{\cdot}0796 \times 1{\cdot}1126$, maximum breadth lies in the testicular field. Cuticular spines present in transverse rows right upto a little posterior of the caecal endings. After the acetabulum cuticular spines become more and more apart from each other. A reniform collar is always present, not continuous ventrally. The collar is quite muscular, and armed with 39 stout collar spines, in all. In arrangement, there are 5 terminal spines on each side, lying together in a typical manner, and these are smaller in size than the normal collar spines. These marginal spines are 29 in number, and are continuous dorsally, 6 of these forming a separate 2nd row higher than the lower main row of 23 and alternating with them. Thus the arrangement becomes $(6+23+10=39)$ and there is a distinct symmetry in their arrangement. The spines appear to be chitinous. The maximum width of the collar is 0·382. The average dimension of the marginal spines is $0{\cdot}0357 \times 0{\cdot}0428$, and the average dimension of the terminal spines is $0{\cdot}01785 \times 0{\cdot}008925$. All the spines are pointed inwards, and they are slightly curved towards the tip. The rounded base of the spines is embedded in the collar musculature and they are capable of movement in the live worm.

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The acetabulum is large, just postbifurcal, not far from the oral sucker. The radial muscles are much wider in the posterior half of the acetabulum. The acetabulum measures 0·465 in diameter. Oral sucker though well developed, is relatively very small and feeble, is ventroterminal, and is rounded, measuring 0·1494 in diameter. The prepharynx in this species is distinctly longer than the oesophagus and it is well developed, measuring 0·15 in length. The pharynx is well developed and orange-shaped, almost equal in size to the oral sucker. Oesophagus quite short, 0·1162 or a little more in length. The intestinal ceca long and extending upto the posterior region, stopping short of the posterior end, unlike the other genera of this subfamily.

All figures drawn with the help of camera lucida :

ABBREVIATIONS

ACET, acetabulum ; CIR, cirrus ; CS, cirrus sac ; CVR, median vitelline reservoir ; CVD, median vitelline duct ; ES, terminal spines ; EXP, excretory pore ; FG, female genital opening ; HC, head collar ; INT, intestinal caeca ; MG, male genital pore ; MS, marginal spines ; OC, ovicapt ; OS, oral sucker ; OES, oesophagus ; OV, ovary ; OT, ootype ; OVD, oviduct ; PPH, prepharynx ; PH, pharynx ; T1, T, anterior and posterior testis RSU ; receptaculum seminis uterinum ; SG, mehlis' gland ; SR, 2nd row of spines ; VGL, vitelline glands.

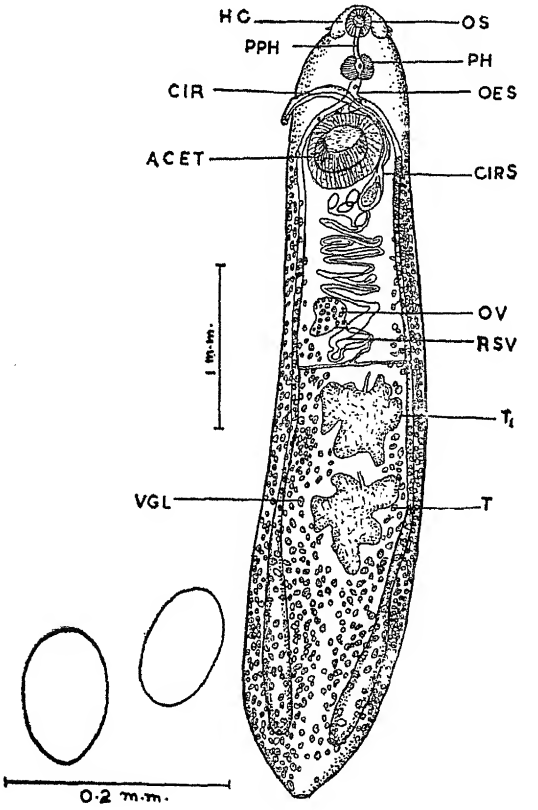

Fig. 1. Ventral view of *P. larueiformis*, with 2 eggs.

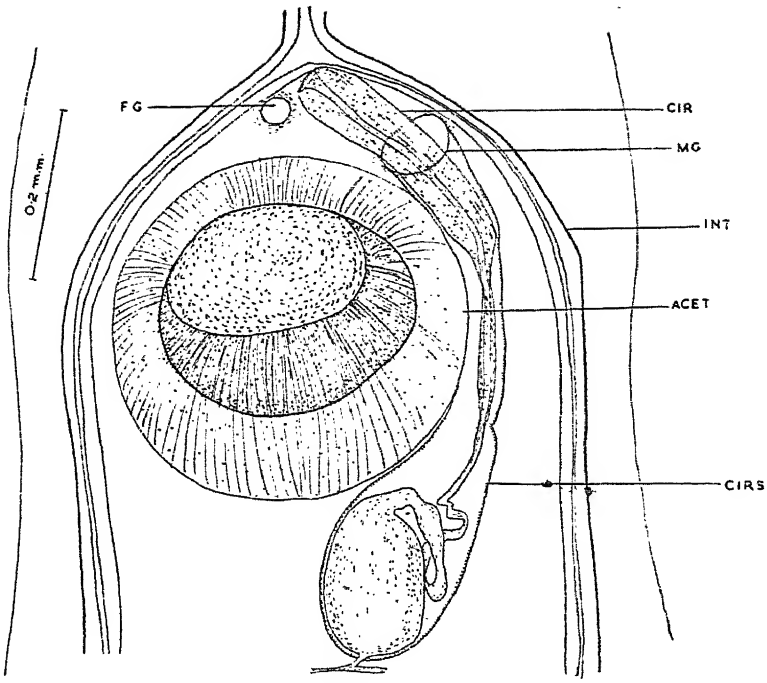

Fig. 2 Male genitalia, Ventral view.

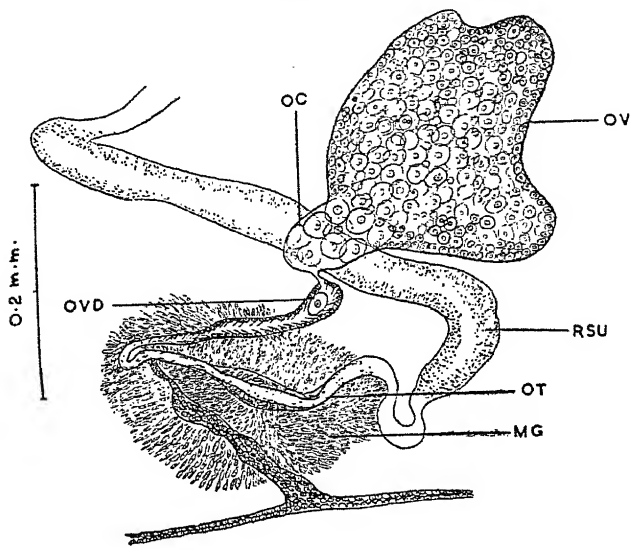

Fig. 3. Female genitalia, Dorsal aspect.

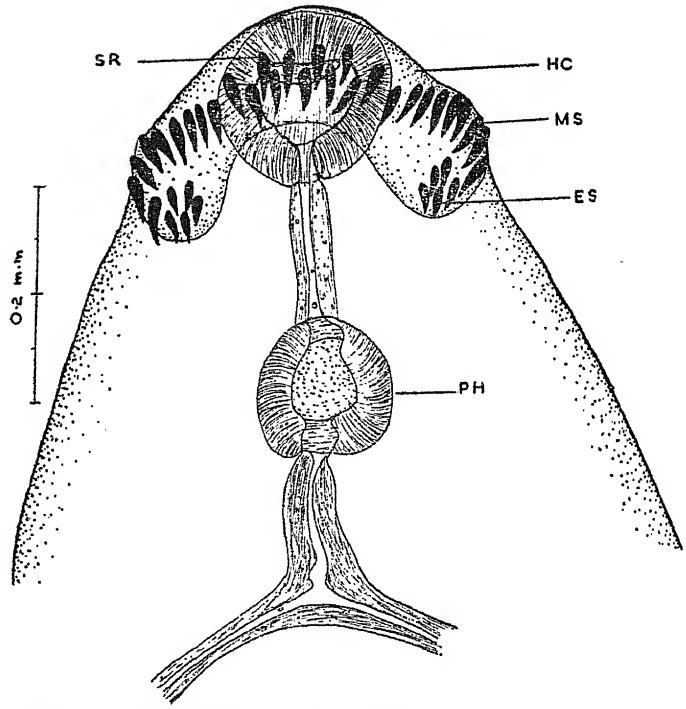

Fig. 4. Anterior portion of body showing arrangement of spine.

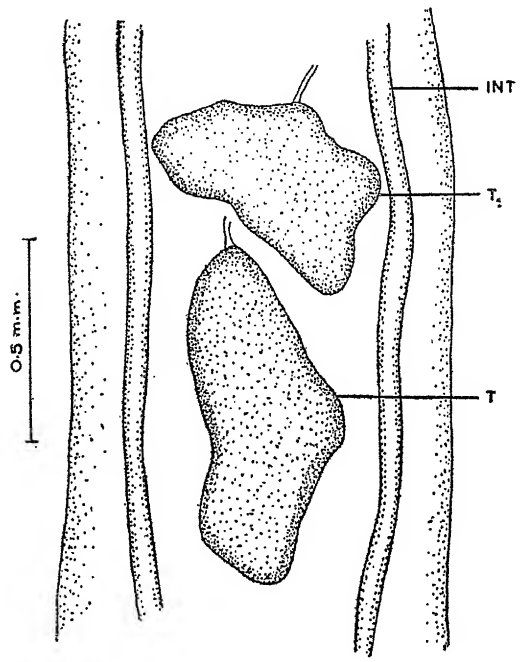

Fig. 5. Anterior drawing of testes.

The testis are situated in the middle of the hindbody, tandem, quite large, and are very irregularly shaped, never, deeply lobed as in the other genera of group. The size of the testes may be equal or unequal. Each testis from the anterior middle gives off a vas eferens which goes by the inner sides of the ceca and finally the two vas eferentia join and form a very short vas deferens, and a postacetabular, saccular, seminal vesicle is formed. The seminal vesicle measures 0·1826×0·1. The anterior and posterior testes measure 0·5478×0·3818 and 0·4316× 0·5478 respectively. The seminal vesicle gives out a stout duct which describes cloop by the side of the seminal vesicle, proceeds upwards and then forms the pass prostatica, which is quite straight and thick-walled, surrounded by very few prostatic glands. The short ductus ejaculatorius is followed by a powerful and highly extensible cirrus, which is made up of longitudinal muscle fibres ; it has a funnel-like opening at its tip, and through the wide male genital pore, which is situated obliquely anterior to the right of the acetabulum, the cirrus sometimes can protrude out well beyond the body margin. The size of the cirrus sac is 0·2158× 0·830. Ovary is small and is somewhat lobed or elliptical, and is situated on the right side and above the anterior testis. From the median left of the ovary arise the oviduct. The ovary in these parasites is always provided with a sizeable knob-like inward protrusion to which is joined the very slender interior end of the oviduct. The knob-like protrusion or "ovicapt" (Dawes, 1946) is probably meant for spacing out the ova as they leave the ovary and passes them in a thin steady streams along the oviduct during the period of egg production. The ova in this worm are quite big. The oviduct, at least in a good initial length is quite thick and the wall is ciliated. The size of ovary is 0·2158×0·2324. The oviduct after proceeding towards the left, sharply bends and proceeds towards the right where it is joined by the vitelline duct, and after this comes thick-walled ootype position. From the ootype the descending or the posterior uterus emerges, and after describing only a small loop it starts ascending. A good initial portion of this uterus is very wide and full of seminal fluid, and hence, in this worm 'receptaculum seminis uterinum' is present. The receptaculum seminis proper as well as the laurer's canal is absent in this genus. The rest of the ascending uterus is not much ; proceeding in a zig zag fasion, and crossing the cirrus sac or the acetabulum, and forming any conspicuous metraterm it opens to the outside by a separate and relatively much smaller ventral female genital opening which is situated towards the right in the same postbifurcal fashion as the male pore does. The ootype region is surrounded by a huge Mehlis' gland. The vitelline follicles, starting from the mediolateral plane of the acetabulum runs marginally, and becomes more and more circumoesophageal until just after the posterior testis the follicles of the two sides come very close, but do not actually merge into each other. This tendency of coming close persists a little beyond the anterior testis even. (Fig. 1). The follicles are small in size, and they extend right upto the posterior end. Just above the anterior testis the two common vitelline ducts come out and in the median plane form a small vitellinereservoir, which is connected by a conspicuous thin-walled canal to the eviduct rather slantingly. The egg production seems to be quite slow, more than 5 eggs have not been observed in any of the 25 specimens, and some contained no eggs at all. The eggs are very large, thin-walled, and light yellow in colour, elliptical in shape, measuring from 0·1245× 0·0747 to 0·1079×0·0664.

The excretory vesicle comes in the Y-shaped category, with cornua quite short, and the cylinderical median position. The cornua end just below the posterior testis, the excretory opening being quite terminal.

Host	...	*Varanus*
Location	...	Foregut.
Locality	...	Jabalpur, India.

Generic diagnosis : *Pseudoartyfectinostomum* n.g : Subfamily. *Paryphostominae* :

Body lanceolate, tapering near the posterior end, as well as the anterior end, broadest in the testicular plane. Head collar reinform, not continuous centrally with a crown of about 39 spines or less, of which the corner or terminal spines are distinctly smaller, and the marginals are arranged in a single row laterally and in two alternating uniterrupted rows dorsally. Oral sucker small pharynx almost as large ; oesophagus very short, prepharynx distinctly longer than oesophagus ; ceca terminating short of posterior extremity, leaving a small postcecal region. Acetabulum large, not far from the oral sucker, in anterior fourth of body. Testes very irregular in shape, or relatively not deeply lobed at all, tandem, in the middle of the hindbody, cirrus pouch long, extending well beyond acetabulum, inclining over left side of acetabulum enclosing a saccular seminal vesicle, a looping seminal duct with a highly muscular, well developed and very much extensible cirrus. Separate male genital opening, immediately preacetabular. Ovary relatively small slightly lobed on its outer margin or rounded, situated to the right side ; laurer's canal and receptaculum seminis absent ; literus extending preacetabulary with a not very extensive zig zag ascending duct, containing 1 to 5 or more very large eggs. Female genital opening separate immediately in front of acetabulum. Excretory opening terminal, excretory Y-shaped, ending just below the posterior testis.

Host	..	*Varanus*
Location	...	*Intestine*
Type specis	...	*Pseudoartyfechinastomum larueiformis* n. sp. n.g.

A revised definition of the subfamily *Paryphostominae* Mendheim, 1943 is given below in the light of the new studies :

Subfamily diognosis : *Paryphostominae* Mendheim 1943, (*Echinostomatidae*).

Body not very small, tapering near anterior and posterior region or only anteriorly ; more or less elongate. Collar beset with upto 47 spines arranged in a single or double rows. Cuticular spines arranged in transverse rows, may extend well upto the posterior region. Ventral sucker rounded, situated in anterior fourth of body, and is very large. Oral sucker small, ventrosubterminal. Pharynx well developed, prepharynx short or long, oesophagus usually short, ceca long. Testes irregularly shaped deeply lobed or not, median and tandem, in or near the middle field of posterior body. Cirrus pouch inclined over left or right of acetabulum, small or extending posterior or to acetabulum. Ovary relatively small, submedian, nearer to anterior testis. Uterus extensive or not, with eggs of moderate to a large size, which may be very few or numerous. Vitellaria extending in lateral fields of hindbody merging posttesticularly or not, extending right upto the posterior extremity. Excretory vesicle Y-shaped, usually bifurcating behind testes. Parasitic in intestinal region of reptiles, birds and mammals.

Distribution	...	cosmopolitan.
Type genus	...	*Paryphostomum* Dietz, 1909.

Tables 1, 2, 3 are given below for the facility of comparision between the 3 genera, and their respective species. Moreover, a new key is adduced to indicate the 3 genera. The tables 1 and 2 have been drawn with due modifications after Jain (1960).

TABLE 1

Genus : *Paryphostomum* Dietz, 1909

Species	*P. radiatum* Diyasdin, 1845	*P. segregatum* Dietz, 1910	*P. testifolium* Gogate, 1934	*P. horai* Bough, 1950	*P. pentalobum* Verma, 1936	*P. dollfusi* Agarwal, 1958	*P. bubbulcusi* Agarwal, 1958
Host	*Plecanus carbo*	*Cathartes usubutinga*	*Dendrocygama jawanica*	*Anas poecilorhyncha*	Snipe	*Bubbulcus ibis*	*Bubbulcus ibis*
Size	3·3–6·5	3·75–8·8	3·5–5·0	3·05–	18·5	11·08–13–·36	8·44–10·85
Collar spines	27 single row	27 double row	27 single row	36 single row	35 double row	46 single row	47 single row
Cuticular spines	Pre-acetabular	Pre-acetabular	Pre-acetabular	Pre-acetabular	Spiny cuticle	lacking	lacking
Ration suckers	1 : 3	1 : 3	1 : 5	1 : 3·8	1 : 3	1 : 5	1 : 4·5
Testes	4–5 lobed	4–5 lobed	3 lobed (all deeply lobed)	3 lobed	5 lobed	5–7 lobed rosettelike	6 lobed rosettelike
Cirrus sac	Small	Small	Small	Small	Small	Small	Small
Vitelline follicle	Starting from well below acetabulum, extending upto the posterior extremity, not merging or coming close in the posttesticular field, in all these.						

TABLE 2

Genus : *Artyfechinostomum* Lane, 1915

Species	*A. sufrartyfex.* Lane, 1915	*A. indicum* Bhalerao, 1931	*A. mehrai* (Faruqui) Jain, 1957
Host	Pigs and Human beings	*Uromastix hardwicki*	White rat
Size	9·0	7·5–8·1	8·36
Collar spines	39 in a single row	42 in double rows	43 in double rows
Cuticular spines	Cuticle spiny upto the posterior testis	Upto the ovarian region	Spine all over the body excepting hinder most region
Ration of the suckers	1 : 5	1 : 3·5	1 : 3·5
Testes	6–7 lobed, deeply lobed	3–7 lobed, deeply lobed	5–6 lobed deeply lobed
Cirrus sac	Elongated, extending upto posterior margin of acetabulum or less, in all these forms.		
Vitelline follicle.	Confluent in the posttesticular median line in all forms.		

TABLE 3

Genus : *Pseudoartyfechinostomum* n.g.

Species		*P. laruciformis* n.sp.
Host	...	*Varanus* sp.
Size	...	Upto 5·5
Collra spines	...	39 in double rows
Cuticular spines	...	Extent upto the cecal endings.
Ratio of suckers	...	1 : 3·12
Testes	...	Irregular in shape never deeply lobed.
Cirrus sac	...	Inclined over left side of ventral sucker extends beyond acetabulum.
Vitelline follicles	...	Start from the middle of acetabulum, coming without merging posterior to testis.
Special feature	...	Ovicant ; receptaculum seminis uterinum ; longer prepharynx ; end spines smaller than other collar spines.

Key to the genera of subfamily *Paryphostominae* Mendheim, 1943.

1. Vitellaria confined to postacetabular region.....2
   Vitellaria beginning from acetabular region.....3

2. Vitellaria not coming close in posterior field, cirrus pouch small never coming beyond 1st 3rd of acetabulum ; collor spines 27–47..... .....*Paryphostomum*

3. Testes irregularly shaped, never deeply lobed, Vitellaria close enough but not confluent posttesticularly..... 4

   Testes very deeply lobed and many lobed ; vitellaria confluent post-testicularly ; cirrus pouch longer, inclined over acetabulum, dextral, collar spines 39–43 ; body broad and rounded posteriorly..... ....*Artypechinostomum*

4. Vesiculum seminis postacetabular and sinistral ; collar spines 39, with end spines smaller ; eggs very few largest of the 3 genera..... ....*Pseudoartyfechinostomum*

Discussion :

As it must be clear from the revised definition of subfamily *Paryphostominae* Mendeim 1943, the three genera have been rightly placed here in this subfamily. However, it is necessary to indicate distinctly the salient features of the new genus, earning for it this status. The genus *Pseudoartyfechinostomum* n.g. has the following distinctly unique feature, owing to which it definitely stands midway of the genus *Paryphostomum*—possibly the latter is a more highly evolved genus—and the genus *Artyfechinostomum* :

1. A hitherto unreported reptilian host *Varanus*.
2. Tapering of the body near the ends, narrower body, and a body with a mediocre size, covered with cuticular spines even below the last 4th of the body.
3. 39 symmetrically placed collar spines with definitely smaller terminal spines.
4. Prepharynx longer than oesophagus. Cecal endings not posteriorly in reach.
5. Testes very irregular in shape, never deeply-lobed, with postacetabularly situated seminal vesicle.
6. Ovary with distinct ovicapt, peculiarly disposed oviduct, pecularly receiving its common vitelline duct, absence of receptaculum seminis, and the presence of a massive receptaculum seminis uterinum, more extensive vitellaria after the 1st this of the body, but the two columns keep distinctly separate inspite of coming very close.
7. Lastly, this genus possesses the largest and fewest egg when compared with the rest of the subfamily.

All the above mentioned characters are lacking in the 2 other genera of the subfamily, and the key and charts drawn above very well point out the separating factors, and the points of similarity, and of course, the latter make it fit for the subfamily *Paryphostominae* Mendheim, 1943, revised.

Obviously, this author is in full agreement with Jain (1960*a*) and with Yadav (1959), who have rightly justified the separate entity of the genus *Artyfechinostomum* Lane, 1915, agreeing with Mendheim, 1943. He further agrees with Jain (1960*a*) for maintaining, with the inclusion of the genus *Artyfechinostomum*, the subfamily *Parypostominae* Mendheim, which has been dissolved by Yamaguti (1958). Jain has given a proper classification of the two then existing genera and keys to their respective species. Another clarification needed here is that Yamaguti (1958) has wrongnly revived the genus *Testisacculus* Bhalerao 1927, for Bhalerao (1932) himself had expunged the genus and transferred his new species to *Paryphostomum* Dietz, 1909, which has been subsequently rightly called as *Artyfechinostomum indicum*, Bhalerao by Mendheim (1943), Jain (1960*a*) and Yadav (1959).

Agarwal (1959)—has described two new species of the genus *Paryphostomum* Dietz, 1909, which have compelled him to give an emended diagnosis of the genus *Paryphostomum* ; as well as the present modifications. This author cannot say much about these two new species of Agarwal (1958) at the moment, but certain features of these two species, *viz.* the enhanced number of collarspines, (2) absence of cuticular spines are quite remarkable features ! This flare in number of collar spines has definitely brought their taxonomic value to the level of specific diagnosis. However, a close study of the two forms does not give us enough reasons to uphold both the species. The mere characters of the oral sucker's size, which very often depends upon the age of the host also (and the size of *P. bubbulcusi* as given by the author himself, when along with certain other anatomical features, does reflect to a certain extent that this particular specimen is probably younger in age) ; and differences of a single spine in the collar (47 in *P. bubbulcusi* and 46 in *P. dollfusi*) are not quite convincing for making the two species. At the same time in the absence of the number of the parasite studied by the author of these two species, and in the absence of my own studies on this particular form no definite remark can be made, except that the two species are possibly the same.

Summary :

While surveying the reptilian fauna of Jabalpur region for termatode parasites two very interesting worms were discovered from the duodenum of *Varanus* sp. The new worm here is being described under the name of *Pseudoartyfechinostomum larueiformis* n.g., n.sp. The new genus, apart from being found from a new reptilian host has many characters of external and internal anatomy which easily differentiate it from the other members of the subfamily *Paryphostominae*. In this paper a revised definition of the subfamily *Paryphostominae*, comparative tables of the genera, and a key to the 3 genera have been given. A brief discussion on some of the studies on the subfamily has been given.

Acknowledgement :

The author is gratified to Dr. G. P. Jain, formerly of the Department of Zoology, Mahakoshal Mahavidyalaya for his kind guidance and help in this work. Thanks are also due to Dr. R. N. Singh, Head of the Department of Zoology, M. M. V. for his kind help and advice and Principal U. Mukerjee* of Mahakoshal Mahavidyalaya for his kind support. Gratefulness is expressed to the University of Jabalpur and the Minsitry of Scientific Research and Cultural Affairs, Government of India for providing a Research Training Scholarship and other monetary assistance for carrying out this work.

*Late Principal.

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STRUCTURE AND BEHAVIOUR OF THE CHROMOSOME OF *MEGALAIME HAEMACEPHALA INDICA*. (LATHAM) (PICIFORMES CAPITONIDAE)

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Introduction :

The study of the avian chromosomes though started since the dawn of this century still remains in a very unsatisfactory state. It involves many difficulties *viz.* (*i*) the determination of the exact number of chromosomes (an extraordinary hard task owing to the large number and the minute size of most of them), (*ii*) the detailed analysis of the chromosomes at prophase stages (rendered difficult owing to the overcrowding of the chromosomal threads), (*iii*) the observation of the second meiotic divison (as it takes place very rapidly), (*iv*) to these may be added the frequent clumping of the chromosomes which increases the observational difficulties at all stages.

In spite of all these handicaps a number of workers in Europe, America and Japan have contributed to the growth of our knowledge. The previous workers have mostly confined their studies to the chromosome number. Chromosomes of Indian birds have not been studied at all. If investigations have been pursued, the object of study has been the domesticated birds. In the present study, however, the author has made an effort to extend our knowledge further by the study of wild birds also. It has been attempted to study the complete meiosis in *Megalaime haemacephala indica* a representative of the family Capitonidae.

Material and Method :

Gonads of a number of adult specimens of *Megalaime haemacephala indica* (Latham) were fixed during the breeding season in Champy's fluid modified by Nakamura (1928). The gonads were fixed at different hours. After usual dehydration and clearing the material was embedded in paraffin and sectioned at 10–12 microns. After bleaching with 4% solution of hydrogen peroxide the sections were treated with Chura's fluid, and Newton's Gentian violet. Heidenhains Iron-haemotoxylin and Feulgen reagents were employed as stains.

As the material under study proved to be difficult for the study of the second meiotic cycle (because the process of division is very quick and short-lived) the birds were injected intramuscularly with a weak solution of colchicine about 4 hours before they were sacrified for the fixation of the gonads. The strength of the solution employed was 1 mg. for 100 cc. of distilled water and the quantity injected varied from 0·5 to 2 ml. depending upon the size and the weight of the specimen. The diagrams were made with the aid of a camera lucida, using 1/12 oil immersion objective and 25X ocular at a level of about 25·6 cm. below the stage, the magnification of all the diagrams being X4000.

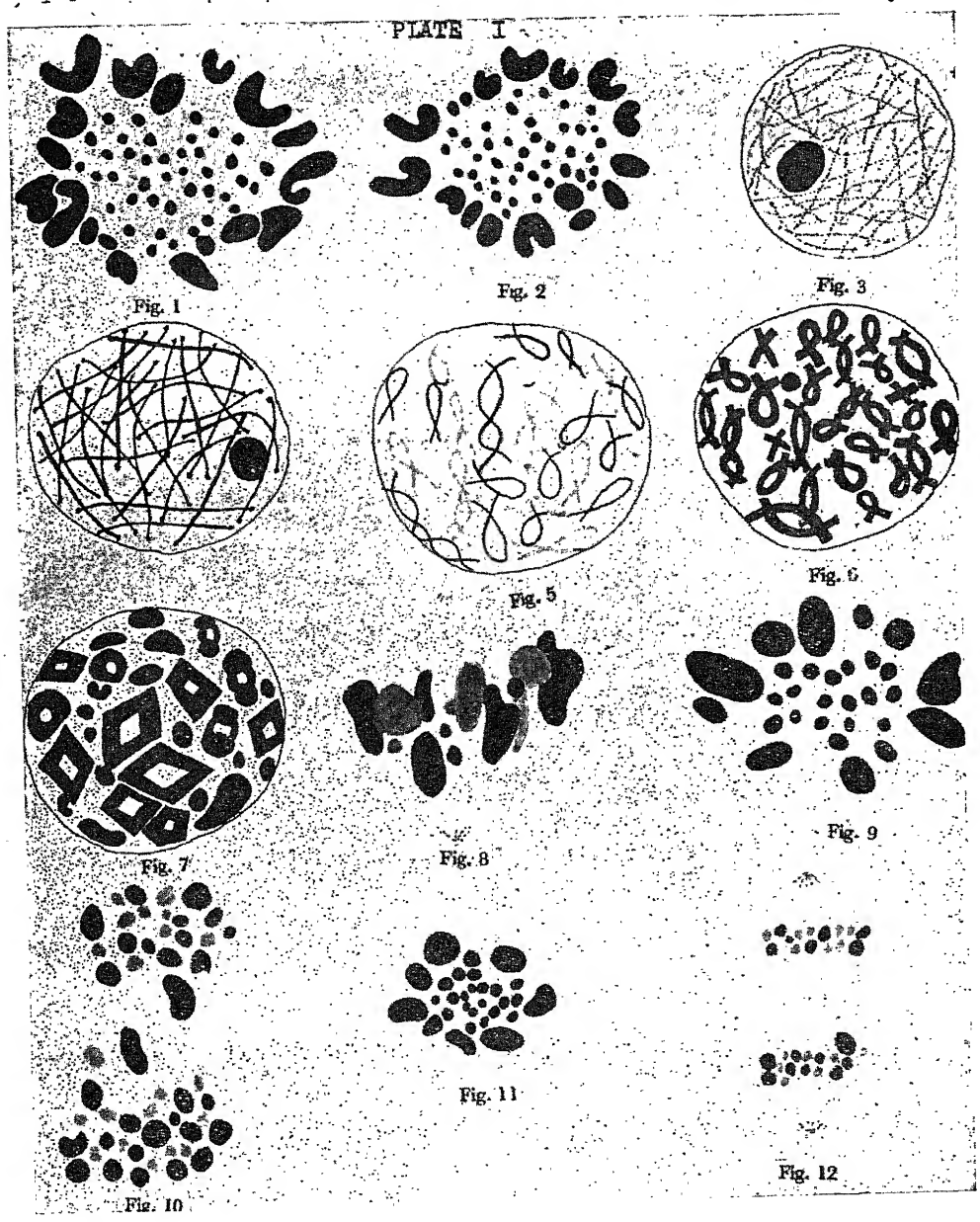

PLATE I

Fig. 1. Sperm atogonial metaphase of *M. haemacephala indica*, showing 58 chromosomes (polar view).
Fig. 2. Oogonial metaphase of *M. haemacephala indica*, showing 57 chromosomes (polar view).
Fig. 3. Leptotene nucleus, showing fine chromosomes threads, the heteropycnotic mass represents the fused sex-chromosomes
Fig. 4. Pachytene nucleus, showing chromosomes threads thickened and shortened, heteropycnotic mass persists.
Fig. 5. Diplotene stage of meiosis ; heteropycnotic mass indistinguishable.
Fig. 6. Diakinetic stage of meiosis.
Fig. 7. Late diakinetic stage.
Fig. 8. First meiotic metaphase (side view).
Fig. 9. First meiotic metaphase, showing 29 chromosomes (polar view).
Fig. 10. First meiotic anaphase, showing lagging behind of two large chromosomes (side view).
Fig. 11. Second meiotic metaphase, showing 29 chromosomes (polar view).
Fig. 12. Second meiotic anaphase, showing clumping of the chromosomes (side view).

Observations :

The diploid number of chromosomes at the spermatogonial metaphase of *Megalaime haemacephala indica* is 58. The chromosome garniture (Plate 1, Fig. 1) shows a typical avian feature in having two distinct size groups of macro- and micro-chromosomes. As usual the macro-chromosomes occupy the peripheral zone of the plates surrounding the micro-chromosomes which lie scattered in the central region. The macro-chromosomes are seen in 9 pairs which may be analysed as— a pair of J-shaped, two pairs of large and small V-shaped and three pairs of kidney-shaped chromosomes (more or less equal in size). Of the remaining three pairs, two pairs are rod-shaped and one pair of spherical chromosomes.

A formula expressing the different shapes of the macro-chromosomes can be expressed as :

$$aJ + bV + cK + dK + eK + fR + gv + hr + is = 18$$

The micro-chromosomes are 40 in number. They are all acrocentric in nature varying in shape and size from short rods to minute spheroids.

The diploid number of chromosomes at the oogonial metaphase plate is 57 (Plate 1, Fig. 2). The chromosomes show a close resemblance to those at the spermatogonial metaphase except that the macro-chromosomes are only 17 in number; one less than in the male. The numerical difference is due to the fact that the large V-shaped chromosome is devoid of its homologue.

Meiosis :

The chromosomes at the leptotene stage are extremely thin and faintly stained threads, running into one another and therefore a satisfactory observation of their structure could not be made (Plate I, Fig. 3). Lying on one side of the leptotene nucleus towards the periphery is observed a deeply-stained heteropycnotic mass. At zygotene the actual pairing of the chromosomes could not be observed. At pachytene the chromosomes are thickened and are more deeply-stained (Plate I, Fig. 4). The excentrically situated deeply-stained heteropycnotic mass is still conspicuous. The diplotene nucleus, as usual, exhibits the separation of the homologues of the bivalents from each other except at the chiasmata (Plate I, Fig. 5), The number of chiasmata ranges from 1 to 3 according to the size of the bivalents. The heteropycnotic mass disappears at this stage and the sex-chromosomes become indistinguishable from the autosomes. The bivalents at the early diakinesis carry the same number of chiasmata as at the diplotene and differ from those af the previous stage, only in being more condensed (Plate I, Fig. 6). At the diakinesis (Plate I, Fig. 7) the bivalents show a still greater degree of condensation. Their chiasmata are seen undergoing progressive terminalization. Some of them are completely terminalized and the remaining ones are moving towards the ends.

At the first spermatocyte metaphase (Plate I, Fig. 8) the chromosomes are seen distributed along the equatorial plate of the spindle. The polar view (Plate I, Fig. 9) shows 29 deeply-stained elements of two size-groups ; of macro- and the micro-chromosomes.

At the first anaphase the homolgues of the bivalents separate and move towards the opposite poles. It has been noted that the two largest chromosomes are delayed in reaching the poles (Plate I, Fig. 10). Interkinesis is of long duration.

At the second metaphase, the distribution of the chromosomes is more or less in conformity with the pattern observed at the first metaphase except that the

chromosomes are smaller and less densely stained. The second metaphase, in polar view, shows 29 chromosomes (Plate I, Fig. 11). Counting of chromosomes becomes difficult due to their clumping. The second anaphase is rarely observed. After intensive search a few patches show this stage, wherein the chromosomes are seen dividing equationally. The divided halves are received by the opposite poles of the spindle. The minute size of the chromosomes and their overcrowding create a difficult situation for determining their exact number. So a detailed study of the chromosomes at this stage is not possible (Plate I, Fig. 12).

The chromosome counts at the various stages of mitosis and meiosis are as follows :

Spermatogonial metaphase	...	56A+X+X	=58
First metaphase	...	29 (bivalents)	=29
First anaphase	..	29 (univalents)	=29
	...	29 (univalents)	=29
Second anaphase	...	29 (univalents)	=29
Oogonial metaphase	...	56A+X	=57

Discussion :

That the sex-chromosomes exhibit positive heteropycnosis during the meiotic prophase is a well established fact. This phenomenon undoubtedly occurs in *Megalaime haemacephala indica* and the sex-chromosomes lie as a fused heteropycnotic mass during the prophase stage in the male meiosis right up to the pachytene stage. It is remarkable to note that although in the male the sex-chromosomes are heteropycnotic, in the female they are not condensed at the meiotic prophase.

Many workers are dealing with different materials (mostly invertebrates) have reported the sex-chromosomes to be positively heteropycnotic in the males and showing no sign of condensation in females (Stevens 1905 and 1909 ; Smith 1952). The author is however, not in a position to generalise this statement for *Megalaime haemacephala indica* owing to insufficiency of data. In reptiles too, which is the other member of Sauropsida, Nakamura 1928, 1931 and 1932) reported the sex-chromosomes to be showing positive heteropycnosis.

In *Megalaime haemacephala indica* the sex-chromosomes are distinguishable owing to the numerical differentiation between the spermatogonial and oogonial metaphase plates. It has been found that the oogonial metaphase of *Megalaime haemacephala indica* has 57 chromosomes *i.e.* one less than the spermatogonial metaphase. The large V-shaped macro-chromosomes which remains unpaired in the female is thus supposed to be the sex-chromosome. The sex-determining mechanism in the species under study is therefore of the XX : X0 type.

During the course of the present investigations the author came across an abnormal behaviour on the part of certain chromosomes at the first anaphase. It has been found that a pair of largest chromosomes always lag behind, while the other chromosomes are proceeding to the respective poles of the spindle. Some workers are of opinion that the sex-chromosomes have a tendency to lag behind. The author has, however, no positive proof to corroborate this statement. According to Darlington (1937) the equilibration of forces operating between the poles (centrosomes) and each centromere of the paired chromosomes is responsible for the regular congression of the chromosomes on the metaphase plate. The lying off of the plate of the X-chromosome, he states, is due to the lag in the centric reaction on account of the nuclear environment being in advance

of the charges in side the chromosome itself. The overcrowding of the chromosomes on the plate has also been considered as one of the causes for the chromosome lying off the plate (Koller and Darlington, 1934). The author, however, is inclined to believe that in *Megalaime haemacephala indica* the lagging behind of certain chromosomes results from the overcrowding of the chromosomes as the chromosome number is very high in the class Aves.

From a comparison of the Karyotypes of *Megalaime haemacephala indica* and *M. asiatics* of the family Capitonidae having the formula 2J+4V+6K+4R+2S+40r=58 and 18R+42r=60 respectively, it has been found that these species show no morphological and genetical similarity with each other. The family Capitonidae shows some interesting Karyotypes and further investigations of the members of this family might reveal more interesting results.

Summary :

1. The diploid number in the male and female of *Megalaime haemacephala indica* is 58 and 57 respectively.
2. The large V-shaped chromosome is the sex-chromosome and the sex-determining mechanism is XX : X0 type.
3. The phenomenon of heteropycnosis is clearly observed.
4. Meiosis is normal. 1st and 2nd metaphase show 29 bivalents and univalent chromosomes respectively.
5. Lagging behind of largest chromosomes is clearly observed at the 1st anaphase.

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INFLUENCE OF VITAMINS ON THE GROWTH RESPONSE OF SOME *PHYLLOSTICTA* SPECIES

By

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Introduction :

Earlier work on physiology of yeasts and animals emphasized the role of small doses of complex organic substances which were named as vitamins by Funk (1914). They have also been called as growth promoting substances, accessory growth factors, nutrilites, auximones or auxithals, etc. It is now well realized that every living organism needs vitamins to accomplish all the vital functions of life. Since the classical work of Schopfer (1934), such studies are receiving consiberable impetus. Though numerous scattered reports are available on filamentous fungi but the pioneer contributions are mainly of Robbins and his coworkers as well as Lilly and his associates, who have extensively studied the vitamin requirements of a number of organisms under varying experimental conditions. Such work has received comparatively little attention in this country and specially the studies dealing with pathogenic fungi are very few only. Sadasivan and Subramanian (1954), Grewal (1954), Agarwala (1955), Tandon and Bilgrami (1957) and Suryanarayanan (1958) have investigated the influence of various vitamins (their different concentrations and combinations) on the development of some of the plant pathogens. A critical perusal of the literature shows that there is no consistency in the response of various pathogenic fungi towards different vitamins. They may suffer with single or with multiple deficiency. Their demand for a particular vitamin from external source may be partial or total. Proper assessment for their requirement may be difficult in those cases where the needs are modified in the changed cultural environments. A particular organism may be self sufficient under normal circumstances and it may be capable of synthesizing the desired type as well as amount of vitamins from the raw ingredients of the culture solution but slight change in the growing atmosphere may volunteer the necessity for extraneous provision. The growth promoting substances may influence both the rate as well as absolute amount of hyphal development. Generally the external supply of favourable vitamins accelerates the growth rate of fungi, though some of the organisms are reported to accomplish the same mycelial development even on a vitamin free medium but under such conditions they require longer incubation period to reach their maximum growth. Higher vitamin concentrations are harmful or even inhibitory for fungal growth. It is, therefore, essential to restrict the doses of vitamins to a requisite level only.

Materials and Methods :

Twelve pathogenic species of *Phyllosticta* were selected for the present investigations. Influence of seven vitamins *viz.*, thiamine, biotin, pyridoxine, riboflavin, nicotinic acid, *p*-aminobenzoic acid and pantothenic acid was examined. The method suggested by Mathur *et al.* (1950) was used for the purification of the

medium. The vitamin deficiencies of the various isolates were evaluated in purified liquid basal medium* which was provided with a mixture of vitamins (thiamine 100 µg, biotin 10 µg, pyridoxine 50 µg, riboflavin 50 µg, nicotinic acid 50 µg, pantothenic acid 50 µg, and *p*- aminobenzoic acid 50 µg, per litre). The effect was studied by excluding one single at a time from the mixture. The flasks of the control series were devoid of vitamins. The inoculum was prepared from conidia which were washed thrice with double distilled water by centrifugation. Seeding was accomplished by pipetting, 0·25 cc of standardized spore suspension (approximately 200 spores). The inoculated flasks were incubated at 25°C. Growth records were taken after 5, 10 and 15 days of incubation. At the end of each incubation period the fungal colonies were thoroughly washed and were subsequently filtered on previously dried and weighed Whatman's filter paper No. 42. Fungus containing filter papers were subjected to 65°C temperature in electric ovens for two days after which they were cooled and accurately weighed.

Observations :

Growth records were taken after 5, 10 and 15 days of incubation. The results are assembled in Table 1.

Table 1 shows that in the absence of external vitamin supply the growth of the species under study was very poor. During the first five days none of the isolates showed any trace of growth on a vitamin free medium. In every case the growth was only 15 to 25% of what they produced on the medium which was furnished with all the seven vitamins. Withdrawl of thiamine from the mixture depressed the growth of all the organisms to a considerable degree. The vegetative development of most of the species was only slightly more than what they accomplished on the vitamin free medium. In one case (*P. glaucispora*) thiamine was so essential that the growth was similar on media lacking thiamine alone or lacking all the vitamins. Slight supression in growth of most of the species was also observed when biotin was removed from the mixture of vitamins. The effect was more pronounced on *P. bauhiniae*, *P. carica-papayae* and *P. pandanicola* while *P. morifolia* and *P. gloucispora* did not seem to have any external requirement for biotin. Exclusion of other vitamins did not have any significant depressive effect on the growth of these isolates. Omission of pyridoxine was of slight advantage to *P. carica-papayae* while absence of riboflavin from the mixture was beneficial to most of the species except *P. morifolia* and *P. pandanicola* where the growth was not influenced by the presence or absence of this vitamin (riboflavin). Elimination of nicotinic acid or *p*-amino benzoic acid was favourable for all the isolates of *Phyllosticta* under study. The degree of advantage by the absence of these vitamins, however, varied with the species.

The preceding results show that elimination of thiamine in all the species and biotin (in majority of them) depressed the growth. It was, therefore, decided to study individually the influence of various concentrations of these two vitamins on the development of twelve species of *Phyllosticta*.

Influence of different concentrations of thiamine :

Influence of different concentrations of thiamine on the the growth of *Phyllosticta* species is recorded in Table 2.

* Glucose 10 g ; KNO_3, 3·5 g ; KH_2PO_4, 1·75 g ; $MgSO_4.7H_2O$, 0·75 g ; distilled water 1 litre.

TABLE 1

Showing the dry weight (in mg.) of twelve species of *Phyllosticta* obtained after 5, 10 and 15 days of growth on media containing different vitamins.

Combination of vitamins	Days of incubation	Names of the species											
		P. bauhiniae	*P. buteae*	*P. flavidula*	*P. carica-papayae*	*P. dracaenae*	*P. eriobotryae*	*P. dardanoi*	*P. kigeliae*	*P. mortoni*	*P. morifolia*	*P. glaucispora*	*P. pandanicola*
All vitamins	5	52	36	52	48	80	50	62	38	59	46	30	62
	10	100	70	120	108	140	120	99	69	100	90	61	111
	15	123	80	160	138	174	166	144	88	124	100	82	140
All –thiamine	5	6	0	0	7	10	0	6	0	12	8	0	8
	10	19	10	16	18	26	13	19	7	25	20	8	22
	15	38	29	39	32	50	38	37	22	39	40	22	40
All –biotin	5	16	20	39	19	50	51	29	19	39	30	20	18
	10	59	51	99	46	120	109	81	58	72	76	57	46
	15	96	68	140	88	152	140	120	76	108	98	77	90
All –pyridoxine	5	51	40	79	71	69	56	46	41	50	41	49	59
	10	96	62	136	137	130	99	97	78	91	87	74	86
	15	128	76	170	156	166	132	130	96	118	106	90	122
All –riboflavin	5	69	40	90	71	80	70	69	40	60	40	37	69
	10	100	76	141	136	159	136	108	71	103	87	80	104
	15	136	92	184	166	182	148	96	130	102	106	142	142
All –nicotinic acid	5	70	36	82	59	72	63	70	36	59	53	40	67
	10	112	71	141	104	121	109	120	70	91	89	73	121
	15	140	84	172	146	180	158	150	82	120	122	98	150
All –pantothenic acid	5	71	50	69	70	86	90	66	70	59	49	49	72
	10	112	79	119	120	139	142	99	96	112	89	81	136
	15	154	102	170	160	192	186	150	106	152	118	106	172
All –*p*-aminobenzoic acid	5	79	41	71	69	86	69	69	40	51	49	42	71
	10	121	80	140	109	152	121	118	80	106	89	80	136
	15	160	92	180	152	198	174	162	98	134	118	110	164
Vitamin free	5	0	0	0	0	0	0	0	0	0	0	0	0
	10	8	10	10	6	20	12	10	8	6	16	16	10
	15	26	20	32	26	38	26	22	18	24	26	22	26

Results from Table 2 show that even slight amount of extra thiamine profoundly enhanced the growth of all the species of *Phyllosticta*. 100 µg/litre of thiamine gave optimum growth of nine species. *P. carica-papayae*, *P. mortoni* and *P. morifolia* needed higher concentration *viz.*, 200 µg/litre for giving maximum hyphal output. A supply of 400 µg/litre or 500 µg/litre had inhibitory effect. Fungi, of every class and habitat are known to be partially or totally deficient for thiamine. Some of such well known species are : *Phycomyces blakesleeanus* (Schopfer, 1938) ; *Pythium butleri* (Robbins and Kavanagh, 1938) ; *Blastocladia pringsheimii* (Cantino, 1948) ; *Sordaria fimicola* (Lilly and Barnett, 1947) ; *Ceratostomella* species (Robbins and Ma, 1942) ; *Trichophyton violaceum* (George, 1951) ; and species of *Piricularia* (Suryanarayanan, 1958). The range of partial deficiency for thiamine may be from slight to almost complete. Higher doses of thiamine were harmful for the present species of *Phyllosticta*. The growth of *Rhizopus nigricans* (Schopfer, 1938) was adversely influenced by any external supply of thiamine. As a single vitamin source it (thiamine) has also been shown to be growth depressant for *Colletotrichum lindemuthianum* (Mathur *et al.*, 1950) ; *Rhizopus suinus* (Schopfer andGuillond, 1945) and *Fusarium lini* (Wirth and Nord, 1942). This vitamin has mainly been attributed to play its role in the metabolism of pyruvic acid. It was reported by Wirth and Nord (1942) as well as Friend and Goodwin (1954) that pyruvate got accumulated in thiamine deficient cultures. Its partial replacement by oxalacetic acid further supports its attributed role (George, 1951). Kavanagh (1942) mentioned that all the organisms which require thiamine or its moieties indicate the functioning of a carboxylase system.

TABLE 2

Showing the dry weight (in mg.) of species of *Phyllosticta* at various concentrations of thiamine obtained after 15 days incubation

Concentration of thiamine	Names of the species											
	P. bauhiniea	*P. buteae*	*P. flavidula*	*P. carica-papayae*	*P. dracaenae*	*P. eriobotryae*	*P. dardanoi*	*P. kigeliae*	*P. mortoni*	*P. morifolia*	*P. glaucispora*	*P. pandanicola*
10µg/litre	64	42	70	44	56	84	80	30	54	38	40	88
100µg/litre	130	68	148	112	160	138	118	72	86	72	86	132
200µg/litre	118	56	140	130	148	130	106	62	110	96	78	120
400µg/litre	100	46	122	106	124	118	92	54	94	82	66	102
500µg/litre	72	38	102	94	108	96	80	50	88	68	56	88

Influence of different concentratiens of biotin :

Influence of concentrations of biotin on the growth of *Phyllosticta* species is recorded in Table 3.

TABLE 3

Showing the dry weight (in mg.) of twelve species of *Phyllosticta* on media containing different concentrations of biotin

Concentration of biotin	Names of the species											
	P. boutiniae	*P. buteae*	*P. flavidula*	*P. carica-papayae*	*P. dracaenae*	*P. eriobotryae*	*P. dardanoi*	*P. kigeliae*	*P. mortoni*	*P. morifolia*	*P. glaucispora*	*P. pandanicola*
10μg/litre	116	76	152	114	160	124	86	78	122	120	122	114
20μg/ltre	136	94	178	128	162	144	118	92	126	112	108	134
40μg/litre	124	73	160	120	142	120	94	70	104	94	92	126
50μg/litre	106	60	138	86	130	102	70	58	82	78	68	90
100μg/litre	86	46	116	70	106	84	59	42	70	62	52	70

It is clear from Table 3 that the present species of *Phyllosticta* satisfied their biotin requirement at a much lower concentration than that of thiamine. Mostly the fungi have been reported to need only a dilute strength of this vitamin. A concentration of 20 μg/litre was most beneficial for all the organisms under study. *P. dracaenae* and *P. mortoni* required a still lower dilution as they made almost identical hyphal development at 10 μg/litre or 20 μg/litre. *P. morifolia* and *P. glaucispora* showed declining tendency beyond 10 μg/litre. Other species gave deleterious expressions, when the strength of biotin was raised beyond 20 μg/litre. The growth of *P. carica-papayae* and *P. pandanicola* was, however, not much influenced upto a concentration of 40 μg/litre. Hawker (1939) observed that certain strains of *Melanospora destruens* could grow in complete absence of biotin but increase of concentration within certain limits improved the growth. The fungi under investigation behaved in the same manner. Robbins and Ma (1942) while working with *Ceratostomella* species, reported that vitamin deficiencies of the two isolates of *C. ips* were different. Strain No. 438 was completely deficient for biotin and only partially deficient for pyridoxine and thiamine while strain No. 255 was completely deficient for all the three vitamins. The present species of *Phyllosticta* however, differed considerably from the isolates of *Ceratostomella* as they did not exhibit any such sharp variations. They, however, differed only slightly in their comparative degree of deficiency though the general pattern of all the species was similar. Divergent vitamin deficiencies for different strains of the same species are also reported for *Boletus granulatus* (Melin and Nyman, (1941) ; *Marasmius perforans* (Lindeberg, 1944) and *Ophiostoma ulmi* (Fries, 1943).

It has been emphasized in the literature that vitamin deficiencies can be partially overcome by changing the cultural conditions. In order to evaluate the deficiency for thiamine and biotin the nitrogen source (potassium nitrate) of the basal medium was replaced by ammonium nitrate, asparagine and aspartic acid.

Influence of nitrogen sources on vitamin requirements :

The dry weight values of 12 species of *Phyllosticta* obtained after 15 days of incubation on thiamine free nitrogen sources are recorded in Table 4.

TABLE 4

Showing the dry weight (in mg.) of 12 species of *Phyllosticta* on different thiamine free nitrogen sources

Nitrogen sources -thiamine	Names of the species											
	P. bauhiniae	*P. buteae*	*P. flavidula*	*P. carica-papayae*	*P. dracaenae*	*P. eriobotryae*	*P. dardanoi*	*P. kigeliae*	*P. mortoni*	*P. morfolia*	*P. glaucispora*	*P. pandanicola*
Ammonium nitrate -thiamine	10	12	14	14	12	19	11	13	11	17	10	15
Potassium nitrate -thiamine	36	31	32	30	43	30	34	23	31	37	8	31
Asparagine -thiamine	64	44	40	54	66	48	39	36	46	48	34	48
Aspartic acid -thiamine	56	38	48	46	58	38	48	27	39	41	27	37

Table 4 shows that the change of nitrogen source influenced the growth of these species but the deficiency for thiamine was not overcome. Replacement of potassium nitrate by ammonium nitrate was inferior while the two organic nitrogen sources, *viz.*, asparagine and aspartic acid were better substitutes. *P. bauhiniae* and *P. carica-papayae* showed a fairly good degree of improvement on asparagine. Except for *P. flavidula* and *P. dardanoi*, all other species showed slightly better response on amide (asparagine) than on aspartic acid. The results thus clearly show that change of the nitrogen source can not complete the deficiency for thiamine. Suryanarayanan (1958) also made similar observations while working with sevearl pathogenic isolates of *Piricularia*.

Influence of nitrogen sources on biotin requirement of different species of *Phyllosticta* is recorded in Table 5.

The results from Table 5 show that replacement of potassium nitrate by ammonium nitrate was more unsatisfactory for all the organisms. Hyphal development of two species viz., *P. dracaenae* and *P. eriobotryae* was brought down considerably. The vegetative development of most of the species improved when asparagine was substituted for potassium nitrate. Growth of three species viz., *P. dardanoi*, *P. kigeliae* and *P. glaucispora* was, however, similar on potassium nitrate or asparagine containing culture solutions which were devoid of biotin. Three species viz., *P. bauhiniae*, *P. carica-papayae* and *P. pardanicola* which showed poor growth on potassium nitrate medium devoid of biotin developed much better on media containing

aspartic acid without biotin. Interesting results were obtained for *P. eriobotryae*, *P. morifolia*, *P. mortoni* and *P. glaucispora* where biotin free aspartic acid medium had its superiority over the same solution supplemented with this vitamin.

TABEL 5

Showing the dry weight (in mg.) of twelve species of *Phyllosctita* attained after 15 days of incubation on various sources of nitrogen which were devoid of biotin

Nitrogen sources –biotin	Names of the species											
	P. baulhiniae	*P. buteae*	*P. flavidula*	*P. carica-papayae*	*P. darcoense*	*P. eriobotryae*	*P. dardanoi*	*P. kigeliae*	*P. mortoni*	*P. morifolia*	*P. glaucispora*	*P. pandanicola*
Ammonium nitrate –biotin	50	34	88	72	46	38	84	40	72	58	49	60
Potassium nitrate –biotin	88	60	130	94	142	142	116	82	96	92	80	88
Asparagine –biotin	106	69	152	136	166	131	119	84	109	102	86	112
Aspartic acid –biotin	117	72	140	138	196	150	130	126	122	93	86	134

Discussion :

Fungi synthesize various vitamins at different rates and their degree of deficiency depends upon their comparative rate of synthesis. The species of *Phyllosticta* selected for the present studies were only partially deficient for thiamine and to some extent for biotin also. The partial deficiencies were less obvious and their range may vary from slight to almost complete. A study of vitamin concentration is therefore, always advisable. Proper selection of doses may be still difficult in those cases where the organisms suffer with multiple deficiency. The species of *Phyllosticta* included in these studies showed some variations for the optimum concentrations of thiamine and biotin.

Higher concentrations of these vitamins were depressant for the growth. The change in the cultural conditions was able to overcome the deficiency for biotin but not for thiamine. Aspartic acid has also been shown to have biotin sparing effect for several other fungi. Those deficiencies which are overcome by changed cultural or environmental conditions have been termed as conditional deficiencies. The total deficiency of *Phycomyces blakesleeanus* and *Ceratostomella fimbriata* (Lilly and Barnett, 1951) to thiamine is, however, not altered by environmental conditions. Such deficiencies have been referred to as absolute deficiencies. Several factors like temperature (Lilly and Leonian, 1945) ; pH (Lilly and Barnett, 1951) ; nitrogen sources (Fries, 1943) and carbon sources (Suryanarayanan, 1958) are reported to modify the vitamin requirements of fungi. The present species of *Phyllosticta* expressed considerable uniformity for their requirement of thiamine and biotin. It is, therefore, not possible to select such studies for any taxonomic differentiation of the species.

Summary :

Influence of seven vetamins on the growth response of twelve pathogenic species of *Phyllosticta* was examined. The isolates were capable of accomplishing some growth even on a vitamin free medium. Withdrawl of thiamine considerably depressed the growth of all the organisms. Three species viz., *P. bauhiniae*, *P. carica-papayae* and *P. pandanicola* needed an external supply of biotin also for attaining normal growth. Exclusion of the remaining five vitamins from the mixture did not have any depressive effect. The elimination of nicotinic acid and *p*-amino benzoic acid was advantageous for most of the present isolates. Different concentrations of thiamine and biotin induced varying growth patterns. High concentrations were deleterious. Replacement of potassium nitrate by asparagine or aspartic acid was partially able to overcome the deficiency for biotin while the thiamine requirement could not be even partially fulfilled by the change in the nitrogen source.

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